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Prospective Safety Performance in Construction Industries in Nepal

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ABSTRACT

This research concentrates on exploring systematic partial least squares structural equation modeling (PLS-SEM) for Prospective Safety Performance Evaluation (PSPE) in construction industry, showing causal relationships along with interactions within enablers and goals of PSPE which are taken into account. A questionnaire survey has been selected to test the conceptual model as the methodology with 135 valid respondents among three levels of construction; namely: private, public and International Non-Governmental Organizations (INGOs) construction industry. The value of R^2 for the endogenous latent variable is 0.532. The higher beta value is 0.288 along with a t- value of 4.350, which indicates that safety culture is strongly proportional to safety performance on the site more than any other construct factor. Moreover, private construction with a value of 0.355 ranged in II (Good), public construction with value of 0.316 ranged in III (Fair) and INGO construction with a value of 0.374 ranged in II (Good) range as per Maximum Degree of Membership (MDM) principle. As per the evaluation results, the variation in various construction industry categories in the safety performance practice is analyzed and compared. This research can facilitate the advancement of safety performance in construction industries, as it provides clear insights into the cause-effect relationship of safety performance factors and goals.

KEYWORDS: Safety performance evaluation, PLS-SEM, Smart PLS, Measurement and structure model.

INTRODUCTION

Construction industries have a tag name of being highly hazardous because of the unique nature of the unequally high incidence of accidents and fatalities that widely happen in the construction sector world (López, Ritzel, Fontaneda & Alcantara, 2008; Nabi, El-adaway & Dagli, 2020; Sacks, Rozenfeld & Rosenfeld, 2009). The risk of fatality in construction industry is five times in comparison to manufacturing-based industry, where major injury risk is 2.5 times higher (Sawacha, Naoum & Fong, 1999). Although construction activities contribute to the same high-risk nature all over the world, fatalities in developing countries are three times more than in developed countries (King & Hudson, 1985). In Nepal, the legislative measure for Occupational Safety and Health Administration (OSHA) is not useful for the small unit operating less than 10 labours out of the boundary of the industrial workplace. The International Labour Organization's (ILO) fundamental principle of OSHA is not enlisted yet (Koirala, 2016). Nepal has not yet approved the ILO convention no.155 on OSHA (Olsen, 2009). Trends of construction industrial injury nature in Nepal show that fatal accidents increased from 5 to 13 between 1995 and 2009 (Joshi, Shrestha & Vaidya, 2011; Koirala, 2016; Sanjel, Thygerson, Khanal & Joshi, 2016). The fatality rate was found to be 10.5 in China, 11.5 in India and 29.9 in Nepal per 100000 employees (Hämäläinen, Takala & Saarela, 2006; Koirala, 2016).

Construction firms in developing countries have a huge impact on the economy of the country (Dmaidi, Mahamid & Shweiki, 2016). For example, in many developing countries, major construction tasks account for about 80% of the total capital asset, 10% of their Gross Domestic Product and more than 50% of the

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property investments in fixed assets. All infrastructure facilities needed for developments, such as hydropower, road, buildings, bridges,… etc., are the output of construction (Jekale, 2004). The problems being faced by construction firms in developing nations are undoubtedly more fundamental, more complex and more serious. In developing countries like Nepal, such challenges sit alongside the general conditions of socio-economic stress, chronic resource shortage and general inability to deal with key issues. Further, site incidents impact all facets of construction projects in terms of human, economy, prestige, energy, efficiency and scope (Al-Khaburi & Amoudi, 2018).

Safety performance evaluation is one of the major sections of a safety management system, as it favors information on the quality of the safety system in terms of development, application and output. Researchers have found out that the influencing factor of safety plays a vital role in proper safety performance on the construction site (Zaira & Hadikusumo, 2017). The traditional approach to evaluate safety performance is incident-related data (such as several non-lost time accidents, lost time accident, severity rate and accident cost), generally represented as lagging indicators (Jaselskis & Recarte Suazo, 1994; Wanberg, Harper, Hallowell & Rajendran, 2013). Researchers have found that the traditional approach targeted external factors, but paid a small concentration on internal factors, like safety culture, safety climate, safety behavior, and safety attitude. The joint effort of the Occupational Health and Safety Management System (OHSMS) and Total Quality Management (TQM) concentrates on safety management toward people, making space to human-oriented theories; for instance, historical factors (Sawacha et al., 1999), psychological stress on construction workers (Chen, McCabe & Hyatt, 2017), age of employer and effect of psychological aspects on safety on a construction site (Idrees, Hafeez & Kim, 2017). In recent years, safety performance focused on the social system approach to improve the human/workplace or environment/machine system, while safety culture can be incorporated positively with a team-based approach (X. Wu, Liu, Zhang, Skibniewski & Wang, 2015). The safety climate on a construction site can be improved with supportive positive safety behavior by controlling the negative aspects of behavior (Dongping Fang, Chen & Wong, 2006).

Structural Equation Model (SEM) is a method for estimating, representing and testing a theoretical network of mostly linear relations between observed and construct variables. It is more comprehensive and adjustable than any other path (such as multiple regression, correlation and ANOVA), providing means of governing not only for extraneous variables, but also for measurement errors as well. The conceptual model was drafted in Smart PLS for the simulation task to estimate the effect of construct variables on safety performance on a construction site.

Though having a safety management system on a construction site, due to lack of proper and effective safety performance on a construction site, accident or injury rate is growing day by day, decelerating the workers' capability and the project itself (Islam, Razwanul & Mahmud, 2017). This results in that the project doesn't get completed within the estimated budget and in the targeted time. It is a prime requirement to determine the major factors and their attributes that play a major role in affecting the safety performance on a construction project on-site. The research is carried out to analyze safety performance in construction sites and to identify the relationship of safety performance with safety climate, safety attitude, safety behavior, safety budget and safety culture using SEM. Similarly, PSEP evaluation is carried out in a construction firm to gain a better understanding of interdependence which in turn will help us provide safety performance progress in a construction firm.

In order to study the understanding of the practice of safety performance in Nepalese construction firms, they are categorized into three categories: private, public and INGOs; as all of these three construction types have different safety budget scales, business market policies and ownerships. Moreover, the researchers tried to identify the key factors which acted as barriers to achieve an excellent level of safety performance in all three categories of construction firms.

Influential Factors

In conformation with the impressive primary work, the safety performance level of construction sites is essentially concerned with the following five aspects: safety attitude, safety culture, safety budget, safety climate and safety behavior. Key indicators of the corresponding latent construct or aspect are measured, studied and divided distinctly as follows:

Safety Climate

Safety climate is a psychological aspect that is, in general, the opinion of the state of safety at a particular time (Wiegmann, Zhang, Von Thaden, Sharma & Gibbons, 2004). Some past researchers defined safety climate as the sum of common opinions on safety shared by workers (Zohar, 2010). Safety climate has been widely identified as one of the most important indicators of safety performance (Flin, Mearns, O'Connor & Bryden, 2000; He, McCabe, Jia & Sun, 2020). Although various studies stated that better safety performance is achieved with a greater safety climate, there has not been much discussion about the influence of safety climate (T.-C. Wu, Chen & Li, 2008). Melia and his students have brought and guarded a structured multilevel outlook of safety climate based on the recognition of the agents answerable for every safety climate statement (Meliá, Mearns, Silva & Lima, 2008).

Previous researchers described client safety climate which symbolizes the belief of client management attitude on safety. Earlier researchers stressed on contract ability which symbolizes skill, talent and knowledge to reach contractual demands or requirements (Borgheipour, Eskandari, Barkhordari & Tehrani, 2020; Petrovic-Lazarevic, Perry & Ranjan, 2007). Similarly, pioneers explained that safety management and supervision represent a mixed bag of the process, practice and rules to achieve the targeted safety aim and goals (Petrovic-Lazarevic et al., 2007; Törner & Pousette, 2009). Besides, earlier authors explained that social safety climate symbolizes the attitude of society toward safety (Choudhry & Fang, 2008; Melia et al., 2008). Moreover, some researchers argued that a contractor safety climate that represents the attitude of a contract manager toward safety is the most voted attribute in a latent variable of safety climate (Choudhry & Fang, 2008; Törner & Pousette, 2009).

Hypothesis 1: Safety *climate (SCL) positively affects safety performance.*

Safety Attitude

Crano and Prislin defined attitudes as "the interpretation judgments that summarize and integrate cognitive/affective reactions" (Crano & Prislin, 2006). Donald and Canter run safety research using SAQ over 6 years in more than 40 companies and measured attitudes toward safety in a reliable and valid way, so that attitudes are surely predictive of safety performance (Donald & Canter, 1993). Older workers by age have a better attitude toward safety. If age and tenure are restrained, some attitude systems are predictors of safety performance (Siu, Phillips & Leung, 2003). Researchers studied the work attitudes of employers and their links with safety performance in micro-enterprise firms (Hadjimanolis, Boustras, Economides, Yiannaki & Nicolaides, 2015). Health, safety & environment (HSE) awareness mobile project improves attitude on the site, by improving the concept of risk and observing work safety pipeline construction in Brazil (Araripe, de Paula & Serricchio, 2008). Past researchers showed that the attitude of a worker toward work has a solid positive link with job satisfaction in Pakistan, which in turn reduced accidents in the workplace (Ahmad, Ahmad & Shah, 2010; Paul & Maiti, 2007). A close investigation by system dynamic modeling showed that the mental action of workers' safety attitudes is beneficial to forecast their objectives and behaviors (Shin, Lee, Park, Moon & Han, 2014). Similarly, such studies indicated that attitude is undoubtedly affected by the employer's emotional condition according to a study regarding employers on Spain construction sites (Rodriguez Garzon, Martinez-Fiestas & Lopez Alonso, 2013).

Moreover, attitudes lean on how people observe risks (Milton, Chaboyer, Åberg, Andersson & Oxelmark, 2020). Previous experience of accidents can influence workers' safety attitudes (Canter, 1980). The study marked that workers' safety attitude toward rules and risk-taking mindset can completely impact heavy plant/equipment/crane-related deaths, since many accidents appeared globally by violating regulations and rules in different ways (Guo, Li, Chan & Skitmore, 2012).

Hypothesis 2: *Safety attitude (SA) positively affects safety performance.*

Safety Behavior

Psychologically, behaviors are actions or reactions of things or persons in feedback to internal or external stimuli (Choudhry, 2014). Regular focusing on the unsafe behavior of workers in a construction project will improve safety performance and reduce accidents on-site (Choudhry & Fang, 2008; Li, Zhai, Zhang & Meng, 2020). Poor safety culture can invite risks to human lives. Many studies have been made over the last few years on organizational safety culture, especially to its definitions, enablers and dimensions side by side for the development of tools for determining and controlling its "health" to improve safety performance (Choudhry, Fang & Mohamed, 2007). The safety awareness of the individual worker increases as long as the employer is freely performing tasks or activities that help progress workplace safety (Ye, Ren, Li & Wang, 2020).

The safety capability of the individual employer considers that the employer secures the greatest levels of safety when doing tasks. The safety understanding of the individual employer explains that the employer uses the correct safety procedures for performing the tasks. Peers who actively care for the group of workers explained that employers help or support their co-workers when they are working under risky conditions. Sharing the safety matter among employers in a team explains that employers support co-workers in safety implementation and learning. All the above attributes are explained in research based on safety performance and safety behavior (Neal, Griffin & Hart, 2000). Working safely together, in which the group of workers is considered, given that nobody can work alone, employers should work together safely if they are aware of safety (Li et al., 2020; Törner & Pousette, 2009).

Hypothesis 3: *Safety behavior (AC) positively affects safety performance.*

Safety Culture

Safety culture and safety performance of a project have been well described using the Theory of Planned Behavior (Ajzen & Fishbein, 1977). Research provides proof that safety culture is correlated with parallel parts of safety performance and can be associated with future performance for some measures (Feng & Trinh, 2019; Morrow, Koves & Barnes, 2014).

Construction companies will create a robust safety culture by reacting regularly to routine and unusual threats and unprecedented construction environment events (Feng & Trinh, 2019). Besides, old researchers identified that safety culture at tactical and operational levels is much positively directly proportional to safety performance in construction firms (Qayoom & Hadikusumo, 2019). Similarly, past researcher analysis showed safety culture to recognize that theory and practice could be embedded in order to ensure better safety performance in Romanian construction projects (Moraru, Băbuţ, Cioca, Popescu-Stelea & Vasilescu, 2020).

Attributes of the safety culture latent variable are extracted from research exploring the relationship between safety performance and safety culture in nuclear power operation in America (Morrow et al., 2014). The selected attributes are modified from "nuclear safety" to "construction safety" to fit our research objectives, as shown in Table 1.

Hypothesis 4: *Safety culture (SCU) positively affects safety performance.*

Safety Budget

Safety investment is simply associated with a budget that is implemented in the workplace for injury control measures to secure the health and physical aspects of workers and materials or financial assets of the contractor in any project (Tang, Lee & Wong, 1997). Enough safety investment helps in the execution of the safety program for safety performance (Jiang, Lai, Shan, Tang & Li, 2020; Zou & Zhang, 2009). Many researchers have already shown that safety investment is directly proportional to safety performance (Laufer, 1987; López-Alonso, Ibarrondo-Dávila, Rubio-Gámez & Munoz, 2013; Roy & Gupta, 2020; Tang et al., 1997; Teo & Feng, 2010). Research over a decade on construction sites showed that safety investment is independent on safety performance or is even indirectly proportional to it (Crites, 1995). Safety equipment and safety administration personnel are major components that have been focused on in studying safety investment (Tang et al., 1997). Insufficient allocation of safety investment or budget causes accidents on the site (Tam, Zeng & Deng, 2004). Safety investment is the bottom baseline with the specific objective of minimizing the incidence of injuries rather than representing serviceable cost. In safety investment, there is a huge gap between the degree of importance and real scenario in proper allocation of resources on Thai construction sites (Aksorn & Hadikusumo, 2008). Researchers used some indicators of safety investment construct to study the relationship-based determinants of safety performance on construction sites in India (Patel & Jha, 2016). We are using the same indicators in this research to study the context of Nepal, as shown in Table 1.

Hypothesis 5: *Safety budget (SBU) positively affects safety performance.*

METHODOLOGY

Questionnaire Design

From the above literature review, overall, 32 attributes from 6 major latent questionnaires were designed with the hope for extraction of respondents' opinions or perceptions on different attributes of major 5 practices of safety on construction sites. Five-point Likert-type scale ranging from 1 (strongly agree) to 5 (strongly disagree) was implemented in the study. Taking item SP1 as an example which stated that "I am confident in the safety efficiency of my project", the respondent can frankly choose a number from 1 to 5 on the basis of his/her understanding and working experience. The higher the agreement on the statement, the higher the number chosen by the respondent.

Table 1. Latent factors along with their corresponding indicators

Latent factor	Code	Indicator	Supporting sources
Safety performance	SP1	I am confident in the safety efficiency of my project.	(Patel & Jha, 2016; T.-C. Wu et al., 2008)
	SP2	How do you rate the overall safety performance of the project?	(Patel & Jha, 2016; T.-C. Wu et al., 2008)
	SP3	In my opinion, my project can have the dignity of a zero-incident project.	(Patel & Jha, 2016; T.-C. Wu et al., 2008)
Safety culture	SCU1	People are regularly praised for recognizing & reporting construction safety issues.	(Morrow et al., 2014)
	SCU2	When I make an error, I'm not ashamed to disclose it to my manager.	(Morrow et al., 2014)
	SCU3	Typically, my supervisor is available anytime I have a request or problem.	(Morrow et al., 2014)
	SCU4	I 'm worried about the consequences of making a mistake.	(Morrow et al., 2014)
	SCU5	Personnel will promptly identify & report conditions which may affect the construction safety.	(Morrow et al., 2014)
	SCU6	There's strong coordination regarding construction safety problems impacting my job.	(Morrow et al., 2014)
	SCU7	It is my responsibility to raise concerns relating to construction safety.	(Morrow et al., 2014)
	SCU8	Training at the construction site gives me the insight I need to do my work.	(Morrow et al., 2014)
Safety behavior	SB1	Awareness of the safety of the individual employer, seeing that the worker performs spontaneously tasks that help to improve safety in the workplace.	(Neal et al., 2000; Zaira & Hadikusumo, 2017)
	SB2	The safety potential of the particular workplace, provided that the worker maintains the highest degree of safety at work.	(Neal et al., 2000; Zaira & Hadikusumo, 2017)
	SB3	Understanding of the safety of the particular workplace, provided that the company employs the appropriate safety procedures to do the work.	(Neal et al., 2000; Zaira & Hadikusumo, 2017)
	SB4	Peers who actively take care of the team of employees, evaluating that the employer encourages their fellow workers when they conduct under risky conditions.	(Neal et al., 2000; Zaira & Hadikusumo, 2017)
	SB5	Sharing the safety issues of employees in a community, given that employers assist staff in the field of safety learning & implementation.	(Neal et al., 2000; Zaira & Hadikusumo, 2017)
	SB6	Working together safely, where the community of employees is recognized, as no one ever works alone & employees can work safely together if they are concerned about safety.	(Neal et al., 2000; Törner & Pousette, 2009; Zaira & Hadikusumo, 2017)
Safety attitude	SA1	I thoroughly appreciate the potential threats & monitor them with special caution.	(Araripe et al., 2008; X. Wu et al., 2015)
	SA2	I never minimize the hazard & seek shortcuts, with few to no risk involved.	(Donald & Canter, 1993; Guo et al., 2012)
	SA3	I assume that all activities & accidents should be monitored & that our actions will prevent any risks.	(Shin et al., 2014; X. Wu et al., 2015)
	SA4	I never take chances / disobey the laws/neglect other guidelines to get the job done.	(X. Wu et al., 2015)
	SA5	I never bring to my job destructive energies, which keeps me functioning with my heart.	(Garzón, Martínez-Fiestas & Alonso, 2013; X. Wu et al., 2015)
	SA6	I am very happy with my work, which brings my work productivity & safety in operation.	(Ahmad et al., 2010; Paul & Maiti, 2007)

Latent factor	Code	Indicator	Supporting sources
Safety climate	SCL1	Client's executive attitude towards safety, as contractors are under the client's time pressure.	(Meliá et al., 2008; Törner & Pousette, 2009)
	SCL2	Combination of experience, knowledge & skills that contractors should have to meet the contractual obligations, such as "contractor's selection of part-time enrolment".	(Petrovic-Lazarevic et al., 2007)
	SCL3	A combination of regulations, methods & practices to meet safety policies & objectives, such as "there are massive differences between the technique & the work practice".	(Khosravi, Asilian-Mahabadi, Hajizadeh, Hassanzadeh-Rangi & Behzadan, 2014; Törner & Pousette, 2009)
	SCL4	The process of consistently & efficiently managing the creation, implementation & study of contracts to increase operational & financial performance & reduce risk, such as "there is no specific allocation of resources for safety".	(Petrovic-Lazarevic et al., 2007; Törner & Pousette, 2009)
	SCL5	People's attitudes towards safety, such as "an unsafe worker" is an "unsafe driver".	(Meliá et al., 2008); (Choudhry & Fang, 2008)
	SCL6	Attitudes of contractor management towards safety, like "take a shortcut to make a higher profit".	(Choudhry & Fang, 2008; Khosravi et al., 2014; Törner & Pousette, 2009)
Safety Budget	SBU1	Our company provides every worker with adequate personal protective equipment (PPE).	(D.P. Fang, Huang & Hinze, 2004; Patel & Jha, 2016; Tang et al., 1997)
	SBU2	The company shall pay the medical expenses of injured workers.	(D.P. Fang et al., 2004; Patel & Jha, 2016; Tang et al., 1997)
	SBU3	How do you rate the budget for safety in the project?	(D.P. Fang et al., 2004; Patel & Jha, 2016; Tang et al., 1997)

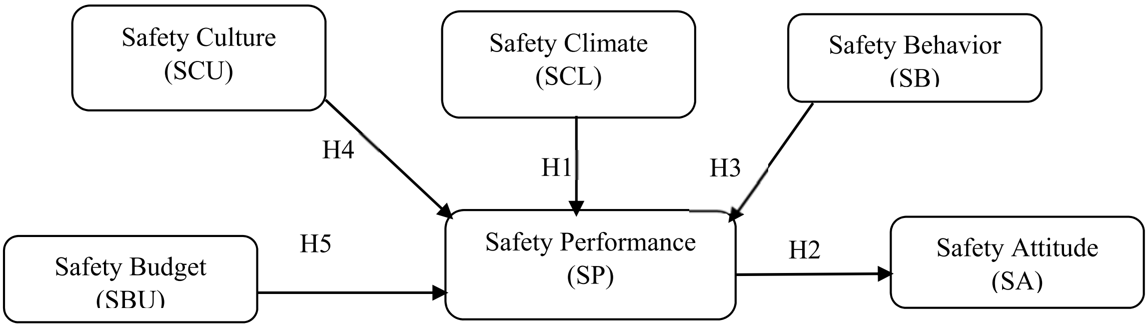

Figure (1): Conceptual model

Response to Questionnaire

Likert scale was used in the questionnaire with 1=Strongly agree; 2=Agree; 3=No opinion; 4=Disagree; 5=Strongly disagree. In this research, respondents were engineers, safety engineers, project managers, contractors…, etc. Construction sites were selected to cover the overall boundary of Nepal. The survey was fully secret and unforced to respondents (free environment to the respondent). A total of 200 questionnaire forms were distributed, among which only 170 were returned back. Out of the 170 feedbacks, 35 were incomplete; i.e., the number of valid responses was 135 and the percentage of the valid responses to the questionnaire was 79.4%, while the percentage of total reply was 85%. Both mail and field surveys were carried out for data collection for analysis. 67% of the respondents obtained hard copies; i.e., were physically present on construction sites and 37% were contacted by e-mail and telephone. The questionnaire was converted into the Nepali language for proper understanding of the questions to get clear responses. From statistical analysis of the demographic information of respondents, most of them were construction engineers, which helps increase the quality of data obtained from the questionnaire and helps strengthen the analysis output to some extent.

RESULTS

We used SPSS, AMOS and Smart PLS v.3 software to carry out analysis in this research. Initially, a preliminary analysis was carried out to check the appropriateness of the data for SEM. Next, a measurement model was tested to confirm the validity of the constructs. The validity of the structural model was tested along with the hypotheses. Lastly, the evaluation process was carried out to find safety performance in different categories of construction.

Preliminary Analysis

Common Method Bias (CMB) may be a challenge when the overall data is accumulated from a common source at a common time (Podsakoff & Organ, 1986). We used Harmon's one-factor test in SPSS to check for CMB; the results approved the absence of CMB from our dataset as the first factor explained only 31.937% of the variance, which was less than the threshold of 50%. Besides, all the Durbin-Watson values were close to 2, demonstrating that the data was free from autocorrelation (Field, 2013).

Additionally, results obtained from the model fit analysis were: "the goodness of fit chi-square value (CMIN/DF=1.375)", "standardized root mean square residual (SRMR=0.0594)", "conformity fit index (CFI=0.957)", "root mean square error of approximation (RMSEA=0.053)", by using AMOS. This clearly shows an excellent mode fit range as per the threshold given (Hu & Bentler, 1999).

PLS-SEM Model Testing and Results

Partial Least Square access to SEM is a substitution to covariance-based SEM, which is appropriate in case that data is not normally distributed, the sample size is small and the correct model details can't be ensured (Chin, 2010; Hair, Ringle & Sarstedt, 2011; Wong, 2013). As in SEM, there are two models in the PLS path model; namely, the structural model and the measurement model. The measurement model determines the relationship between the latent variables and the observed indicators. Similarly, the structural model determines the relationship between the latent variables and unobserved indicators (Ringle, Sarstedt & Straub, 2012). PLS has likely to work with a much higher number of indicators, constructs and their relationships (Chin, 2010). Smart PLS version 3 software was implemented to inspect the reliability and validity of both the measurement model and the structural model.

Analysis and Validity of the Measurement Model

Before the analysis of the structural model, quality examination of the constructs is the prime requirement. Initially, benchmark examination for internal consistency reliability by calculating Cronbach's alpha which estimates reliability is done based on indicator correlations. In the PLS path model, Cronbach's alpha presents a decision estimation of internal consistency reliability of the latent variables, as it infers that all indicators are equally reliable. Composite reliability is assumed as a good measure of internal consistency, as it gives the standardized loadings of the manifest variables (Claes Fornell & David F. Larcker, 1981a). Most of the past authors have approved a rule of thumb showing that an indicator loading above 0.7 is favored to be highly satisfied (Henseler, Ringle & Sinkovics, 2009). From past research view, the threshold value required for a better model was a composite reliability higher than 0.7 (Hair et al., 2011) and a Cronbach's alpha more than 0.7 (Henseler, Hubona & Ray, 2016). Validity analysis is based on two parameters: convergent validity and discriminant validity. Convergent validity is carried out by using the Average Variance Extracted (AVE) on the manifest variables (Claes Fornell & David F. Larcker, 1981a). It helps find out the quantity of variance grabbed by a latent variable with its corresponding manifest variable because of measurement errors. AVE value of a latent variable should be higher than 0.5 (Barclay, Higgins & Thompson, 1995; Claes Fornell & David F. Larcker, 1981c). Discriminant validity is carried out to approve that the manifest variable of any construct is appropriate to the formulated latent variable, where cross-loading value in the latent variable is greater than that in any other construct (Chin, 1998). SCU1, SB3 and SA2 indicators were omitted, as they give outer loadings less than 0.6 and AVE value less than 0.5, in order to upgrade the reliability and convergent validity of the constructs. By running PLS software after omitting unfit indicators, Table 2 shows improved CR, AVE and Cronbach's alpha values which were above the required minimum values as suggested by pioneers, approving adequate convergent validity and reliability of the measurement model. In addition, HTMT calculation is carried out to assess discriminant validity. HTMT of correlation of indicators crosswise calculates various phenomena related to correlation of indicators within the same construct (Henseler, Ringle & Sarstedt, 2015). If the calculated value of HTMT is greater than the threshold value 0.85, it shows that there is absence of discriminant validity (Clark & Watson, 1995; Kline, 2011).

Besides, Table 2 represents that the diagonal item (which is printed boldly in the table) was higher and the square root of the Average Variance Extracted (AVE) latent variable indicates the highest value in any column and row. Non-diagonal numbers signify correlations of the construct with other constructs, Fornell-Larker Criterion (Claes Fornell & David F. Larcker, 1981), also showing satisfactory discriminant validity of the measurement model. Further, cross-loadings of all consistent apparent variables have higher values in comparison to their linked latent variables, as shown in “Appendix A” which also presents supportive discriminant validity.

Table 2. Results of indicator and convergent validity along with mean, S.D. and discriminant validity (Fornell-Larcker Criterion)

Construct	SA	SB	SBU	SCL	SCU	SP	rho_ A/ρA	CR	AVE	CA
SA	**0.83**[a]						0.92	0.916	0.688	0.916
SB	0.25	**0.87**					0.945	0.939	0.756	0.94
SBU	0.29	0.36	**0.839**				0.878	0.877	0.704	0.878
SCL	0.25	0.26	0.33	**0.82**			0.933	0.924	0.672	0.926
SCU	0.19	0.24	0.27	0.169	**0.847**		0.955	0.946	0.718	0.948
SP	0.49	0.49	0.518	0.501	0.488	**0.862**	0.904	0.896	0.743	0.895
Mean	2.54	2.44	2.56	2.6	2.41	2.47				
S.D.	0.957	0.993	0.955	0.997	0.944	1.02				

Note: CR and Cronbach’s alpha values larger than 0.7 show the internal consistency reliability (Gefen, Straub & Boudreau, 2000). AVE values greater than 0.5 signify convergent validity (Bagozzi & Yi, 1988; Claes Fornell & David F. Larcker, 1981b). The non-diagonal numbers signify correlations of the construct with other constructs (Claes Fornell & David F. Larcker, 1981b).

Table 3. Discriminant validity: heterotrait-monotrait ratio (HTMT)

	SA	SB	SBU	SCL	SCU
SA					
SB	0.242				
SBU	0.284	0.355			
SCL	0.243	0.251	0.319		
SCU	0.184	0.236	0.268	0.166	

Note: This table shows that Heterotrait-Monotrait ratio (HTMT) value is under the threshold of 0.9 (Henseler et al., 2015)

Analysis and Validity of the Structural Model

For the analysis and validity of the structural model, we calculate the R^2 value (coefficient of determination) of the endogenous latent variables. Similarly, other parameters in PLS-SEM are assessing path coefficient of a latent variable by beta value, effect size by f^2, predictive relevance Q^2 of the structural model and multicollinearity judgment.

Significance of Path Coefficients of Latent Variables

The path coefficient shows the conventional change of endogenous construct with a unit change in the predictor construct. Beta value is an analysis between all latent variables; the greater the beta value, the stronger or greater the effect of the exogenous (predictor) variable on the endogenous (dependent) variable (Aibinu & Al-Lawati, 2010). Beta value is calculated on the basis of the t-test value. Non-parametric bootstrapping is carried out to obtain the t-value. Bootstrapping technique generates prespecified numbers of samples to calculate t-value. 5000 samples were generated by bootstrapping, which was implemented to calculate t– values (Henseler et al., 2016; Hoonakker, Carayon & Loushine, 2010). Pioneers suggested that (t-value > = 1.96 at p = 0.05 level, t-value > = 2.58 at p = 0.01 level, t-value >= 3.29 at p = 0.001 level) for two-tail test (Hair et al., 2011). We followed the same threshold values. Table 4 shows that all paths obtained t-values greater than the threshold value of 1.96 at 5% significance level. All the paths in the model showed a strong effect on safety performance. Moreover, the highest beta value was 0.288, indicating that safety culture is strongly proportional to safety performance on construction sites.

Table 4. Testing the hypotheses in the structural model

Hypothesis	Relationship	Std. beta	Std. error	t-value	p-values	Decision	5%CI LL	95% CI UL
H1	SCL -> SP	0.253	0.074	3.464	0.001**	Supports	0.131	0.375
H2	SA -> SP	0.258	0.078	3.285	0.001**	Supports	0.134	0.388
H3	SB -> SP	0.215	0.094	2.293	0.022*	Supports	0.061	0.374
H4	SCU -> SP	0.288	0.066	4.35	0.000**	Supports	0.177	0.395
H5	SBU -> SP	0.201	0.071	2.856	0.004*	Supports	0.084	0.316

Note: t-value >= 1.96 at p = 0.05 level, t-value >= 2.58 at p = 0.01 level, t-value >= 3.29 at p = 0.001** level.*

Evaluating Coefficient of Determination R^2, Effect Size f^2 and Predictive Relevance q^2

The value of R^2 for the endogenous latent variable needs to be more than 0.26 (Cohen, Cohen, West & Aiken, 2013; Memon & Rahman, 2014). During calculation, we had the value of R^2 as 0.532 and adjusted R^2 was 0.514, that was higher than the threshold value, which showed that the model was in the feasible degree to describe the variance of safety performance through the constraining factors. Similarly, the effect size f^2 is a measurement of the crash of every exogenous construct on the endogenous construct in the model. The cut-off value of f^2 was 0.02 for small, 0.15 for medium and 0.35 for large structural level (Alsaad, Mohamad & Ismail, 2017; Chin, 1998; Cohen, 1988; Shanmugapriya & Subramanian, 2016). Similarly, q^2 is the predictive relevance of the structural model by implementation of Stone-Geisser's factor which was calculated by using the blindfolding process (Tenenhaus, Vinzi, Chatelin & Lauro, 2005). The q^2 value should be greater than zero for the relevance of the corresponding construct. Table 5 shows that during calculation, all effect size f^2 & predictive relevance q^2 values were in good cut-off range. Moreover, Variance Inflation Factor (VIF) and tolerance were calculated for the assessment of collinearity. A threshold value of VIF was 10 or above and for tolerance, it should be greater than 0.1 when assessing collinearity (Henseler et al., 2009). The results in Table 5 show that all VIF values and tolerance values were within the threshold values, which indicates that there was an absence of collinearity between the exogenous constructs in the model.

Table 5. Effect size f^2, predictive relevance q^2 and variance inflation factor (VIF)

Exogenous variable	Endogenous variable	Effect size (f^2)	Predictive relevance (q^2)	Collinearity Statistics	
				Tolerance	VIF
SA	SP	0.15	0.063	0.887	1.128
SB	SP	0.10	0.048	0.843	1.186
SBU	SP	0.08	0.033	0.807	1.239
SCL	SP	0.15	0.067	0.869	1.151
SCU	SP	0.19	0.087	0.905	1.105

Note: The cut-off value of f^2 is 0.02 for small, 0.15 for medium and 0.35 for large structural level (Alsaad et al., 2017; Chin, 1998; Cohen, 1988; Shanmugapriya & Subramanian, 2016). The q^2 value should be greater than zero for the relevance of the corresponding construct (Tenenhaus et al., 2005). The threshold value of VIF is 10 or above and for tolerance, it should be greater than 0.1 during the assessment of collinearity (Henseler et al., 2009).

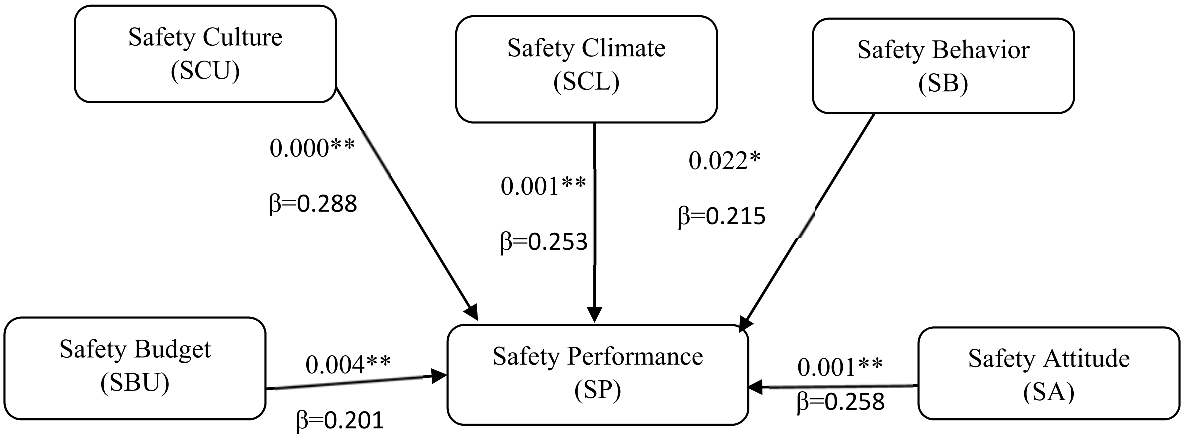

Figure (2): PLS-SEM- model for PSEP for construction industry in Nepal

Evaluation Process

PSEP looks like a difficult evaluation problem, as different thicknesses and influential factors are engaged in the examination. Different researchers used various processes for evaluation, but in this research, we implemented a systematic approach for evaluation of safety performance, which is one the bases of SEM. SEM provides an overall probable causal relationship and communication between goals and enables PSEP. The evaluation process includes three steps as follows.

a. Evaluation Matrix

The main target of PSEP is to find out the problems and appropriate solutions to eliminate the issues of safety performance on construction sites by improving and upgrading safety performance aspects. To identify the major problems, weaknesses and strength aspects of any institution, the working staff can give the real feedback through their experiences. Besides, the collected data from respondents (private, public and INGOs) can be re-used and evaluation ability can be upgraded, as we don't need additional investment. The data was evaluated under 32 indicators from 6 constructs. We used each indicator of each latent construct factor, represented by:

B_{ij}^{ln}= (i=1, 2, 3, 4, 5; j=1, 2, 3; l=1, 2, 3; n=1, 2, 3, 4, 5) (1)

Here, *i* represents the number of predictor constructs and *j* represents several indicators of each construct. As the minimum number of indicators of each of the constructs was three, we chose only 3 indicators whose path coefficients were very high compared to those constructs which included more than 3 indicators (Table 1). Similarly, n represents the base of judgment ranging from 1 (completely agree) to 5 (completely disagree). The higher the judgment, the better will be the safety performance on the site. Evaluation of safety performance was divided into 5 segments "I (excellent), II (good), III (fair), IV (poor) and V (very poor)". The fraction sharing of each indicator was represented by B_{ij}^{ln}, calculated by Eq. (2). The evaluation matrix for the i^th^ fraction sharing of the l^th^ construction type was represented by the vector B_i^l, as shown in Eq. (3).

$$B_{ij}^{ln} = \frac{a_{ij}^{ln}}{\sum_{n=1}^{5} a_{ij}^{ln}} \quad i= 1, 2, 3, 4, 5;\ j=1, 2, 3;\ l=1, 2, 3;\quad m = 1, 2, 3, \ldots.5 \tag{2}$$

$$B_i^l= \begin{bmatrix} B_{i1}^{l1}\, B_{i1}^{l2}\, B_{i1}^{l3}\, B_{i1}^{l4}\, B_{i1}^{l5} \\ B_{i2}^{l1}\, B_{i2}^{l2}\, B_{i2}^{l3}\, B_{i2}^{l4}\, B_{i2}^{l5} \\ B_{i3}^{l1}\, B_{i3}^{l2}\, B_{i3}^{l3}\, B_{i3}^{l4}\, B_{i3}^{l5} \end{bmatrix} \tag{3}$$

b. Weight Determination

After the verification of supportable discriminant and convergent validity, we used the path coefficient values from the PLS model, as shown in Tables 2, 3, 4 and 5. The likelihood of path coefficient output is elaborated by multiplying the ordinary regression coefficient by the standard deviation of the corresponding variable. Supposing σ_{ij}= (i=1, 2, 3, 4, 5; j=1, 2, 3) shows the value of path coefficient of the j^th^ indicator in the i^th^ form. The j^th^ indicator weight in the i^th^ indicator was represented by β_{ij}, obtained by Eq. (4). All indicator weights in the i^th^ form were given by Eq. (5).

Similarly, let x_i (i=1, 2, 3, 4, 5) symbolize the value of path coefficient in the ith form, the ith form weight symbolized by w_i can be gained by Eq. (6). All the aspects of weight can be obtained by Eq. (7).

$$\beta_{ij} = \frac{\sigma_{ij}}{\sum_{j=1}^{5} \sigma_{ij}}, \text{ i=1, 2..5;j=1, 2, 3} \quad (4)$$

$$\beta_i = [\beta_{i1}\ \beta_{i2}\ \beta_{i3}] \quad (5)$$

$$w_i = \frac{x_i}{\sum_{i=1}^{5} x_i}, \text{ i=1, 2…5} \quad (6)$$

$$W = [w_1\ w_2\ w_3\ w_4\ w_5] \quad (7)$$

c. Calculation and Results

The efficient measurement of safety performance helps in deciding to encourage safety performance on construction sites. Based on the evaluation matrix D and the weight matrix W, the extensive evaluation vector of the ith indicator concerning the lth construction group, denoted by P_i^l, was calculated by Eq. (8). Similarly, the extensive evaluation vector of the lth construction group, denoted as P^l, was calculated by Eq. (9). The Maximum Degree of Membership (MDM) principle (Liang & Shi, 2003) was implemented, where the level of safety performance evaluation was identified in such a way that the maximum value within five levels was taken as the final result. For example, P^1 with the distribution (0.2, 0.3, 0.25, 0.27, 0.28) was rated as II (Good), as in the second level it had the maximum value among all five levels.

$$P_i^l = \beta_i \ x\ B_i^l = [P_i^{l1}\ P_i^{l2}\ P_i^{l3}\ P_i^{l4}\ P_i^{l5}], \text{ i=1, 2…5; l=1, 2, 3} \quad (8)$$

$$P^l = W \text{ x } \begin{bmatrix} P_i^{l1} \\ P_i^{l2} \\ P_i^{l3} \\ P_i^{l4} \\ P_i^{l5} \end{bmatrix} \quad (9)$$

d. Analysis of Results

To clarify the detailed calculation process, the collected data of the first indicator (SBU: Safety Budget) of a public construction firm was used as an example. There were altogether 45 respondents and their judgments are shown in Table 6. Eq. (3) was manipulated to evaluate matrix B_i^l of safety budget of a public construction firm. Weights of all indicators of the first aspect were calculated to be β_i [0.324, 0.33 and 0.346] and weights of all five constructs were calculated as W [0.112, 0.296, 0.342, 0.199 and 0.051] from Eqs. (5) and (7). Similarly, the application of Eq. (7) and Eq. (8) gave the final evaluation result of safety performance for public construction calculated as P^l = [0.1995, 0.2333, 0.3158, 0.1796 and 0.0725]. As per the MDM principle, it was at the third (III) level that was in the fair range.

Table 6. Respondent judgements on safety budget on public construction sites

S. N.	Judgement				
	Completely agree (I)	**Agree (II)**	**Fair (III)**	**Disagree (IV)**	**Completely disagree (V)**
SBU1	3	14	15	10	3
SBU2	7	13	12	10	3
SBU3	5	13	19	7	1

$$B_1^1 = \begin{bmatrix} 0.067 & 0.311 & 0.333 & 0.222 & 0.067 \\ 0.156 & 0.589 & 0.267 & 0.222 & 0.067 \\ 0.111 & 0.289 & 0.422 & 0.156 & 0.022 \end{bmatrix}$$

Table 7. The final results of safety performance concerning 3 various construction industry types

Category	Evaluation distribution				
	I (Excellent)	**II (Good)**	**III (Fair)**	**IV (poor)**	**V (Very poor)**
Private	0.178	**0.355**	0.268	0.129	0.066
Public	0.2	0.233	**0.316**	0.180	0.073
INGOs	0.325	**0.374**	0.198	0.130	0.025

DISCUSSION AND IMPLICATIONS

Common Method Bias (CMB) was absent during the analysis, so data was good enough for SEM modeling. Moreover, during the model fit test, all parameters were in the excellent range above the threshold values. The reliability and validity of the outer measurement model and inner structural model were significant. The results of all five-hypothetical paths (H1-H5) in Table 4 demonstrate the significance of the SEM model.

Out of the total 5 hypotheses, 3 direct hypotheses (H1, H2 & H4) were supported at 0.1% significance level and 2 direct hypotheses (H3 & H5) were supported at 1% level of significance, as shown in Table 4. An increase in one standard deviation of the SCL, SA, SB, SCU & SBU constructs would increase 25.3%, 25.8%, 21.5%, 28.8% & 20.1%, respectively, to the standard deviation of SP at (f^2= 0.15, $p<0.001$), (f^2=0.15, $p<0.001$), (f^2=0.1, $p<0.01$), (f^2=0.19, $p<0.001$) & (f^2=0.08, $p<0.01$), respectively.

The examination and identification of the path coefficient of the inner structural model showed that the relationship between safety culture and safety performance in construction was highly significant among all other constructs with the highest t-value of 4.350 and a beta value of 0.288. Morrow proved that safety culture is empirically and statistically significant to safety performance in the nuclear power industry in the USA (Morrow et al., 2014). Similarly, with a t-value of 3.464 and a beta value of 0.253, safety climate showed the second highest significance to safety performance in construction. Previous authors' findings have also supported our result that safety climate is a predictor of construction safety performance (Auzoult & Ngueutsa, 2019; Gao, Chan, Utama & Zahoor, 2016). Moreover, with a t-value of 3.285 and a beta value of 0.258, safety attitude showed moderate significance to safety performance. Past researches supported that safety attitude was a predictor of safety performance in Hong Kong construction workers (Siu et al., 2003). "Confidence in safety" indicator with a loading value of 0.916 represented a major indicator of safety attitude, which was supported by old research (Guo et al., 2012).

Similarly, data analysis results showed that there was a reasonable relation between safety performance and safety budget with a t-value of 2.856 and a beta value of 0.215. Researchers presented significant results between safety budget and safety performance in construction company cost (López-Alonso et al., 2013). Past authors showed that if safety investment was less than demanded, it invited accidents on the construction site, which resulted in worse safety performance (Ma, Zhao & Xi, 2016). Some researchers also showed that safety budget affects safety performance during empirical examination on Indian construction sites (Patel & Jha, 2016). Various analysis results showed that there was a practical relationship between safety performance and safety behavior with a t-value of 2.293 and beta value of 0.215. Past authors found that Malaysian contracting organizations should target effectively high concentration in upgrading employer safety behavior to seek zero accidents on-site (Zaira & Hadikusumo, 2017). Many researchers found that unsafe behavior was a major source of accidents on sites, so safety behavior is proportional to safety performance on any construction site (Choudhry, 2014; Zhang & Fang, 2013).

From the evaluation matrix output which was obtained by implementation of MDM principle, private and INGOs construction firms were in the good range of safety performance, whereas public construction firms were in the fair range in the context of safety performance, as shown in Table 7. This output showed that public construction needed to focus more on all constructs and their items for better safety performance on construction sites. The verified construction sites had a minimum of 2 years of safety training program implemented, but none of them achieved an excellent result. The researchers conducted a casual interview with the respondents to discover the reason for failure to reach an excellent range in the categories of construction. It was noticed that inexperienced and untrained employers were appointed without giving them any training before going to the workplaces. However, employers have been reporting that they have been hiring trained staff or they have been providing training to them. Besides, it was also marked that some safety training used to be conducted after fatal accidents

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on-site or after the pressure of employer to construction firms to show evidence. Moreover, in some cases, passive participation of workers for safety training was a major barrier to achieve excellent results.

PRACTICAL MODEL APPLICATION

To the best of our knowledge, this is one of the first works to determine perceptive safety performance in developing countries, along with the reuse of respondents' structural and measurement valid modeling data to present the safety performance level in three different construction categories; namely, private, public and INGOs. Moreover, we were able to identify the key factors which stopped firms from meeting the excellent range, which were: 'appointment of untrained manpower', 'less importance given to safety training by the construction company' and 'passive participation of workers in safety training'.

PLS-SEM path model has been used in this research, which shows the relationship between latent construct and indicator variables as well as their impact on upgrading safety performance on construction sites in Nepal. The practical utilization of this research is to focus and strengthen the major attributes for safety performance on sites, which can be a guideline to construction professionals. Very few or negligible SEM studies had been carried out in the safety sector on Nepal's construction sites. The model was tested on Nepalese construction sites to figure out safety performance and to boost the construction sector for making a plan to improve safety in the workplace. By comparing the recent situation of construction sites in Nepal with the model benchmark, the required improvement range can be quickly determined for better safety performance. Besides, this model output could be applicable to all developing countries (like Nepal) around the world for the formation of strategies and planning for better safety performance in construction firms.

Moreover, by reprocessing accumulated data from respondents (private, public and INGO construction companies), evaluation aptitude can be promoted, as we don't need to invest and request an expert for performance evaluation, since we can reuse data from respondents. The valid path coefficient from the model was implemented to calculate the evaluation process. The level of safety performance of each category of construction was a range with the application of the MDM principle. From the output of the evaluation matrix, it is clear that we need to focus more on public construction of Nepal, as it is in a critical state in comparison to other categories of construction.

CONCLUSIONS

Construction is ordinarily one of the most dangerous sectors in the global context. The construction industry should concentrate more on the safety environment to maintain zero-accident conditions in the workplace. The construction industry must upgrade the safety measures to improve worker safety status, by providing sufficient safety facilities, improving safety climate and safety culture and providing sufficient financial budget support. Similarly, selecting employers having a positive safety attitude is required to maintain safety behaviour in the workplace.

A conceptual PLS-SEM model for various construction firms of Nepal was hypothesized. With the help of data gained from a questionnaire survey, an empirical study was carried out. 135 valid survey questionnaire responses were used to establish the PLS-SEM model, which was verified through convergent and discriminant validity. Result output showed that there is a strong impact of climate, culture, attitude, budget and behaviour on the safety performance of construction firms.

An organized PSEP was generated by reusing data from a survey showing the interrelationships within indicators for safety performance. Though the study was conducted on selected construction enterprises implementing safety performance programs for at least 2 years, the output obtained was not satisfactory in terms of outstanding performance. From the analysis, private construction and INGO construction achieved a good level, while public construction got a fair level only, as shown in Table 7. Through the responses, it was noticed that experienced and trained employers need to be appointed and safety training should be given as required, not only to show such documentation to the government, but also to improve performance. Moreover, active participation of workers in safety training is a major requirement, which helps achieve excellent results in all (Public, Private and INGO) categories of construction.

In fact, construction firms of Nepal haven't implemented safety programs properly for the improvement of safety performance. By analyzing the output of PSEP, we can get the standard of their construction as they haven't been implementing safety performance properly. It was evident that the construction firms need to go for systematic management of safety mechanisms; by expanding the appropriate implementation process, launching health security programs, constructing emergency action policies, developing proper documentation of events and accidents and giving defined responsibilities and roles to labour. All these steps will not only increase their safety performance, but will also speed up their job in better quality. Besides, record management of accidents that occur on construction sites has not been maintained properly. Firms usually try to hide such cases of accidents to show full safety management; however, the government should leap ahead and find out the real scenario of such cases. The government should make a proper policy which will regulate the record management of accident cases on construction sites. Not only record management, but also proper action should be implemented to reduce such accidents and support such laborers who face such accidents.

RECOMMENDATIONS

Regular inspection for safety checks should be mandatory in any construction firm. Safety budget arrangement should be integrated into BOQ from the initial phase of the project. Disciplinary rules and regulations concerning safety practices should be prescribed. Training and awareness of proper application of safety materials, machines, instruments and PPE should be organized before the beginning of the project. Newly introduced methods, techniques and raw materials should be made user friendly to work in a sound environment. The study explains that the achievement of construction safety performance is not satisfactory. There is a requirement of improvement of the affecting factors determined by the study for Nepalese construction firms to gain effective safety performance. Nepalese construction firms should focus on the determined reasons obtained from the study to achieve an outstanding performance level. Moreover, firms should eliminate safety challenges and problems to promote the safety performance of workers in construction firms.

Appendix A

Cross-loading of all indicators

	SA	SB	SBU	SCL	SCU	SP
SA1	**0.885**	0.210	0.236	0.165	0.230	0.396
SA3	**0.889**	0.257	0.280	0.227	0.162	0.426
SA4	**0.805**	0.119	0.178	0.224	0.034	0.366
SA5	**0.891**	0.254	0.221	0.216	0.132	0.381
SA6	**0.856**	0.140	0.191	0.187	0.192	0.355
SB1	0.186	**0.888**	0.269	0.234	0.243	0.445
SB2	0.151	**0.874**	0.209	0.210	0.158	0.346
SB4	0.304	**0.918**	0.406	0.232	0.220	0.419
SB5	0.192	**0.913**	0.275	0.222	0.193	0.444
SB6	0.189	**0.894**	0.290	0.194	0.213	0.377
SBU1	0.206	0.263	**0.911**	0.257	0.222	0.402
SBU2	0.192	0.305	**0.915**	0.286	0.239	0.409
SBU3	0.291	0.305	**0.863**	0.260	0.204	0.428
SCL1	0.276	0.233	0.330	**0.856**	0.173	0.423
SCL2	0.129	0.155	0.138	**0.853**	0.050	0.338
SCL3	0.118	0.170	0.260	**0.870**	0.100	0.345
SCL4	0.073	0.157	0.183	**0.831**	0.117	0.363
SCL5	0.320	0.351	0.391	**0.877**	0.300	0.471
SCL6	0.232	0.139	0.174	**0.834**	0.026	0.387
SCU2	0.135	0.137	0.209	0.127	**0.868**	0.383
SCU3	0.156	0.164	0.224	0.129	**0.885**	0.393
SCU4	0.148	0.214	0.233	0.090	**0.867**	0.353
SCU5	0.107	0.131	0.157	0.188	**0.831**	0.296
SCU6	0.132	0.197	0.166	0.140	**0.856**	0.391
SCU7	0.211	0.277	0.276	0.142	**0.907**	0.451

SCU8	0.158	0.253	0.225	0.165	**0.889**	0.460
SP1	0.419	0.501	0.405	0.471	0.439	**0.923**
SP2	0.411	0.430	0.433	0.431	0.411	**0.921**
SP3	0.383	0.293	0.423	0.341	0.382	**0.882**

REFERENCES

Ahmad, H., Ahmad, K., and Shah, I. A. (2010). "Relationship between job satisfaction, job performance attitude towards work and organizational commitment". European Journal of Social Sciences, 18 (2), 257-267.

Aibinu, A. A., and Al-Lawati, A. M. (2010)." Using PLS-SEM technique to model construction organizations' willingness to participate in e-bidding". Automation in Construction, 19 (6), 714-724.

Ajzen, I., and Fishbein, M. (1977). "Attitude-behavior relations: A theoretical analysis and review of empirical research". Psychological Bulletin, 84 (5), 888-897.

Aksorn, T., and Hadikusumo, B. H. (2008). "Measuring effectiveness of safety programmes in the Thai construction industry". Construction Management and Economics, 26 (4), 409-421.

Al-Khaburi, S., and Amoudi, O. (2018). "Analysis of accident causes at construction sites in Oman". Jordan Journal of Civil Engineering, 12 (2), 279-293.

Alsaad, A., Mohamad, R., and Ismail, N. A. (2017). "The moderating role of trust in business to business electronic commerce (B2B EC) adoption". Computers in Human Behavior, 68, 157-169.

Araripe, C., de Paula, E.H., and Serricchio, C.U. (2008). "A new approach to work safety awareness for pipeline construction workers". In: 2008 7th International Pipeline Conference (pp. 545-551): American Society of Mechanical Engineers.

Auzoult, L., and Ngueutsa, R. (2019). "Attitude to safety rules and reflexivity as determinants of safety climate". Journal of Safety Research, 71, 95-102.

Bagozzi, R. P., and Yi, Y. (1988). "On the evaluation of structural equation models". Journal of the Academy of Marketing Science, 16 (1), 74-94.

Barclay, D., Higgins, C., and Thompson, R. (1995). "The partial least squares (PLS) approach to casual modeling: Personal computer adoption and use as an illustration".

Borgheipour, H., Eskandari, D., Barkhordari, A., and Tehrani, M. (2020). "Predicting the relationship between safety climate and safety performance in cement industry". Work, 66 (1) ,1-9.

Canter, D.V. (1980). "Fires and human behaviour:" John Wiley & Sons, 84-86.

Chen, Y., McCabe, B., and Hyatt, D. (2017). "Impact of individual resilience and safety climate on safety performance and psychological stress of construction workers: A case study of the Ontario construction industry". Journal of Safety Research, 61, 167-176.

Chin, W. W. (1998). "The partial least squares approach to structural equation modeling". Modern Methods for Business Research, 295 (2), 295-336.

Chin, W.W. (2010). "How to write up and report PLS analyses". In: Handbook of Partial Least Squares (pp. 655-690), Springer, Berlin.

Choudhry, R. M. (2014). "Behavior-based safety on construction sites: A case study". Accident Analysis & Prevention, 70, 14-23.

Choudhry, R. M., and Fang, D. (2008). "Why operatives engage in unsafe work behavior: Investigating factors on construction sites". Safety Science, 46 (4), 566-584.

Choudhry, R. M., Fang, D., and Mohamed, S. (2007). "The nature of safety culture: A survey of the state-of-the-art". Safety Science, 45 (10), 993-1012.

Clark, L. A., and Watson, D. (1995). "Constructing validity: Basic issues in objective scale development". Psychological Assessment, 7, 309-320.

Cohen, J. (1988). "Statistical power analysis for the behavioral sciences". Lawrence Earlbaum Associates, Hillsdale, NJ, 20, 8-16.

Cohen, J., Cohen, P., West, S.G., and Aiken, L.S. (2013). "Applied multiple regression/correlation analysis for the behavioral sciences". Routledge.

Crano, W. D., and Prislin, R. (2006). "Attitudes and persuasion". Annu. Rev. Psychol., 57, 345-374.

Crites, T. R. (1995). "Reconsidering the cost and benefits of a formal safety program". Professional Safety, 40 (12), 28-33.

Dmaidi, N., Mahamid, I., and Shweiki, I. (2016). "Identifying the critical problems of construction contracting management in Palestine". Jordan Journal of Civil Engineering, 10 (1), 67-82.

Donald, I., and Canter, D. (1993). "Psychological factors and the accident plateau". Health and Safety Information Bulletin, 215, 5-12.

Fang, D., Chen, Y., and Wong, L. (2006). "Safety climate in construction industry: A case study in Hong Kong". Journal of Construction Engineering and Management, 132 (6), 573-584.

Fang, D., Huang, X., and Hinze, J. (2004). "Benchmarking studies on construction safety management in China". Journal of Construction Engineering and Management, 130 (3), 424-432.

Feng, Y., and Trinh, M. T. (2019). "Developing resilient safety culture for construction projects". Journal of Construction Engineering and Management, 145, Article ID: 04019069.

Field, A. (2013). "Discovering statistics using IBM SPSS statistics". Sage, London, UK.

Flin, R., Mearns, K., O'Connor, P., and Bryden, R. (2000). "Measuring safety climate: Identifying the common features". Safety Science, 34 (3), 177-192.

Fornell, C., and Larcker, D.F. (1981a)."Evaluating structural equation models with unobservable variables and measurement error". Journal of Marketing Research, 18 (1), 39-50.

Fornell, C., and Larcker, D.F. (1981b). "Structural equation models with unobservable variables and measurement error: Algebra and statistics". Journal of Marketing Research, 382-388.

Gao, R., Chan, A.P., Utama, W.P., and Zahoor, H. (2016). "Multilevel safety climate and safety performance in the construction industry: Development and validation of a top-down mechanism". International Journal of Environmental Research and Public Health, 13 (11), 1100-1117.

Garzón, I. R., Martínez-Fiestas, M., and Alonso, M. L. (2013). "The risk perceived by the construction worker: What role does the trade play?". Journal of Construction, 12(3),83-90.

Gefen, D., Straub, D., and Boudreau, M.-C. (2000). "Structural equation modeling and regression: Guidelines for research practice". Communications of the Association for Information Systems, 4 (1), 1-78.

Guo, H., Li, H., Chan, G., and Skitmore, M. (2012). "Using game technologies to improve the safety of construction plant operations". Accident Analysis & Prevention, 48, 204-213.

Hadjimanolis, A., Boustras, G., Economides, A., Yiannaki, A., and Nicolaides, L. (2015). "Work attitudes and safety performance in micro-firms: Results from a nationwide survey (the opinion of the employees)". Safety Science, 80, 135-143.

Hair, J. F., Ringle, C. M., and Sarstedt, M. (2011). "PLS-SEM: Indeed, a silver bullet". Journal of Marketing Theory and Practice, 19 (2), 139-152.

Hämäläinen, P., Takala, J., and Saarela, K. L. (2006). "Global estimates of occupational accidents". Safety Science, 44 (2), 137-156.

He, C., McCabe, B., Jia, G., and Sun, J. (2020). "Effects of safety climate and safety behavior on safety outcomes between supervisors and construction workers". Journal of Construction Engineering and Management, 146 (1), Article ID:04019092.

Henseler, J., Hubona, G., and Ray, P. A. (2016). "Using PLS path modeling in new technology research: Updated guidelines". Industrial Management & Data Systems, 116, 2-20.

Henseler, J., Ringle, C. M., and Sarstedt, M. (2015)." A new criterion for assessing discriminant validity in variance-based structural equation modeling". Journal of the Academy of Marketing Science, 43 (1), 115-135.

Henseler, J., Ringle, C. M., and Sinkovics, R. R. (2009). "The use of partial least squares path modeling in international marketing". In: New Challenges to International Marketing. Emerald Group Publishing, Limited, 20, 277-319.

Hoonakker, P., Carayon, P., and Loushine, T. (2010). "Barriers and benefits of quality management in the construction industry: An empirical study". Total Quality Management, 21 (9), 953-969.

Hu, L.T., and Bentler, P.M. (1999). "Cut-off criteria for fit indices in covariance structure analysis: Conventional criteria *versus* new alternatives". Structural Equation Modeling: A Multidisciplinary Journal, 6 (1), 1-55.

Idrees, M.D., Hafeez, M., and Kim, J.-Y. (2017). "Workers' age and the impact of psychological factors on the perception of safety at construction sites". Sustainability, 9 (5), 745-762.

Islam, M.S., Razwanul, I., and Mahmud, M. T. (2017). "Safety practices and causes of fatality in building construction projects: A case study for Bangladesh". Jordan Journal of Civil Engineering, 11 (2), 267-278.

Jaselskis, E.J., and Recarte Suazo, G.A. (1994). "A survey of construction site safety in Honduras". Construction Management and Economics, 12 (3), 245-255.

Jekale, W. (2004). "Performance for public construction projects in developing countries: Federal road and educational building projects in Ethiopia". Norwegian University of Science & Technology.

Jiang, F.-C., Lai, E., Shan, Y.-X., Tang, F.-H., and Li, H.-G. (2020). "A set theory-based model for safety investment and accident control in coal mines". Process Safety and Environmental Protection, 136, 253-258.

Joshi, S. K., Shrestha, S., and Vaidya, S. (2011). "Occupational safety and health studies in Nepal". International Journal of Occupational Safety and Health, 1 (1), 19-26.

Khosravi, Y., Asilian-Mahabadi, H., Hajizadeh, E., Hassanzadeh-Rangi, N., and Behzadan, A. H. (2014). "Structural modeling of safety performance in construction industry". Iranian Journal of Public Health, 43 (8), 1099-1112.

King, R.W., and Hudson, R. (1985). "Construction hazard and safety handbook". Butterworth-Heinemann.

Kline, R. (2011). "Principles and practice of structural equation modeling". 3rd Edn., Guilford Press. New York.

Koirala, M.P. (2016). “Health and safety concern of workers of building materials producing industries in Nepal". International Journal of Engineering Research & Technology (IJERT), 5 (12), 16-21.

Laufer, A. (1987). "Construction safety: Economics, information and management involvement". Construction Management and Economics, 5 (1), 73-90.

Li, M., Zhai, H., Zhang, J., and Meng, X. (2020)." Research on the relationship between safety leadership, safety attitude and safety citizenship behavior of railway employees". International Journal of Environmental Research and Public Health, 17 (6), 1864-1880.

Liang, Z., and Shi, P. (2003). "Similarity measures on intuitionistic fuzzy sets". Pattern Recognition Letters, 24 (15), 2687-2693.

López-Alonso, M., Ibarrondo-Dávila, M. P., Rubio-Gámez, M. C., and Munoz, T. G. (2013)." The impact of health and safety investment on construction company costs". Safety Science, 60, 151-159.

López, M. A. C., Ritzel, D. O., Fontaneda, I., and Alcantara, O. J. G. (2008). "Construction industry accidents in Spain". Journal of Safety Research, 39 (5), 497-507.

Ma, Y., Zhao, Q., and Xi, M. (2016). "Decision-making in safety investment: An opportunity cost perspective". Safety Science, 83, 31-39.

Meliá, J. L., Mearns, K., Silva, S. A., and Lima, M. L. (2008). "Safety climate responses and the perceived risk of accidents in the construction industry". Safety Science, 46 (6), 949-958.

Memon, A.H., and Rahman, I.A. (2014). "PLS-SEM analysis of inhibiting factors of cost performance for large construction projects in Malaysia: Perspectives of clients and consultants". The Scientific World Journal, 2014, Article ID: 165158.

Milton, J., Chaboyer, W., Åberg, N.D., Andersson, A.E., and Oxelmark, L. (2020). "Safety attitudes and working climate after organizational change in a major emergency department in Sweden". International Emergency Nursing, Article ID: 100830.

Moraru, R. I., Băbuţ, G. B., Cioca, L. I., Popescu-Stelea, M., and Vasilescu, V.-G. (2020). "Safety culture: A perpetual challenge or an opportunity for Romanian companies?". In: MATEC Web of Conferences. EDP Sciences, 305, 66-74.

Morrow, S. L., Koves, G. K., and Barnes, V. E. (2014). "Exploring the relationship between safety culture and safety performance in US nuclear power operations". Safety Science, 69, 37-47.

Nabi, M. A., El-Adaway, I. H., and Dagli, C. (2020). "A system dynamics model for construction safety behavior". Procedia- Computer Science, 168, 249-256.

Neal, A., Griffin, M.A., and Hart, P.M. (2000). "The impact of organizational climate on safety climate and individual behavior". Safety Science, 34 (1-3), 99-109.

Olsen, L. (2009). "The employment effects of climate change and climate change responses: A role for international labour standards?". GURN.

Patel, D., and Jha, K. (2016). "Structural equation modeling for relationship-based determinants of safety performance in construction projects". Journal of Management in Engineering, 32 (2), Article ID: 05016017.

Paul, P. S., and Maiti, J. (2007). "The role of behavioral factors in safety management in underground mines". Safety Science, 45 (4), 449-471.

Petrovic-Lazarevic, S., Perry, M., and Ranjan, R. (2007). "Improving the occupational health and safety measures in the Australian construction industry". Zagreb International Review of Economics and Business, 10 (2), 17-34.

Podsakoff, P.M., and Organ, D.W. (1986). "Self-reports in organizational research: Problems and prospects". Journal of Management, 12 (4), 531-544.

Qayoom, A., and Hadikusumo, B.H. (2019). "Multilevel safety culture affecting organization safety performance: A system dynamic approach". Engineering, Construction and Architectural Management, 26 (10).

Ringle, C.M., Sarstedt, M., and Straub, D.W. (2012). "Editor's comments: A critical look at the use of PLS-SEM". MIS Quarterly, 36 (1), 3-16.

Rodriguez Garzon, I., Martinez-Fiestas, M., and Lopez Alonso, M. (2013). "The perceived risk by the construction worker: What role does the trade play?". Revista De La Construccion, 12 (3), 83-90.

Roy, S., and Gupta, A. (2020). "Safety investment optimization in process industry: A risk-based approach". Journal of Loss Prevention in the Process Industries, 63, Article ID: 104022.

Sacks, R., Rozenfeld, O., and Rosenfeld, Y. (2009). "Spatial and temporal exposure to safety hazards in construction". Journal of Construction Engineering and Management, 135 (8), 726-736.

Sanjel, S., Thygerson, S.M., Khanal, S.N., and Joshi, S.K. (2016). "Environmental and occupational pollutants and their effects on health among brick kiln workers". Open Journal of Safety Science and Technology, 6, 81-98.

Sawacha, E., Naoum, S., and Fong, D. (1999). "Factors affecting safety performance on construction sites". International Journal of Project Management, 17 (5), 309-315.

Shanmugapriya, S., and Subramanian, K. (2016). "Developing a PLS path model to investigate the factors influencing safety performance improvement in construction organizations". KSCE Journal of Civil Engineering, 20 (4), 1138-1150.

Shin, M., Lee, H.-S., Park, M., Moon, M., and Han, S. (2014). "A system dynamics approach for modeling construction workers' safety attitudes and behaviors". Accident Analysis & Prevention, 68, 95-105.

Siu, O.-l., Phillips, D.R., and Leung, T.-W. (2003). "Age differences in safety attitudes and safety performance in Hong Kong construction workers". Journal of Safety Research, 34 (2), 199-205.

Tam, C., Zeng, S., and Deng, Z. (2004). "Identifying elements of poor construction safety management in China". Safety Science, 42 (7), 569-586.

Tang, S., Lee, H., and Wong, K. (1997). "Safety cost optimization of building projects in Hong Kong". Construction Management and Economics, 15 (2), 177-186.

Tenenhaus, M., Vinzi, V. E., Chatelin, Y.-M., and Lauro, C. (2005). "PLS path modeling". Computational Statistics & Data Analysis, 48 (1), 159-205.

Teo, E. A.-L., and Feng, Y. (2010). "The moderated effect of safety investment on safety performance for building projects". International Journal of Construction Management, 10 (3), 45-61.

Törner, M., and Pousette, A. (2009). "Safety in construction: A comprehensive description of the characteristics of high safety standards in construction work, from the combined perspective of supervisors and experienced workers". Journal of Safety Research, 40 (6), 399-409.

Wanberg, J., Harper, C., Hallowell, M. R., and Rajendran, S. (2013). "Relationship between construction safety and quality performance". Journal of Construction Engineering and Management, 139 (10), Article ID: 04013003.

Wiegmann, D.A., Zhang, H., von Thaden, T.L., Sharma, G., and Gibbons, A.M. (2004). "Safety culture: An integrative review". The International Journal of Aviation Psychology, 14 (2), 117-134.

Wong, K. K.-K. (2013). "Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS". Marketing Bulletin, 24 (1), 1-32.

Wu, T.-C., Chen, C.-H., and Li, C.-C. (2008)."A correlation among safety leadership, safety climate and safety performance". Journal of Loss Prevention in the Process Industries, 21 (3), 307-318.

Wu, X., Liu, Q., Zhang, L., Skibniewski, M. J., and Wang, Y. (2015). "Prospective safety performance evaluation on construction sites". Accident Analysis & Prevention, 78, 58-72.

Ye, X., Ren, S., Li, X., and Wang, Z. (2020). "The mediating role of psychological capital between perceived management commitment and safety behavior". Journal of Safety Research, 72, 29-40.

Zaira, M. M., and Hadikusumo, B. H. (2017). "Structural equation model of integrated safety intervention practices affecting the safety behaviour of workers in the construction industry". Safety Science, 98, 124-135.

Zhang, M., and Fang, D. (2013). "A continuous behavior-based safety strategy for persistent safety improvement in construction industry." Automation in Construction, 34, 101-107.

Zohar, D. (2010). "Thirty years of safety climate research: Reflections and future directions". Accident Analysis & Prevention, 42 (5), 1517-1522.

Zou, P.X., and Zhang, G. (2009). "Comparative study on the perception of construction safety risks in China and Australia". Journal of Construction Engineering and Management, 135 (7), 620-627.