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Original Article

Implementation of Construction Safety Laws in Public and Private Projects: Empirical Evidence from Bangladesh

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Abstract *- In developing countries like Bangladesh, where the safety budget is constrained, implementing safety regulations is the bottom line to confirm safety performance in construction projects. As public and private projects differ in resource allocation and expected outcomes, there is a research question on implementing different types of construction safety laws and their impact on safety performance in public and private projects separately. 172 project managers participated in a structured questionnaire survey to identify the status of how construction safety laws were implemented and safety performance in terms of Safety Behavior (SB), Safety Conditions (SC), and Client Acceptance (CA). After reviewing the current safety rules in Bangladesh, a total of 28 construction safety concern areas were categorized into five subcategories after doing factor analysis: workers' Welfare (WF), Housekeeping (HK), Working Environment (WE), Equipment (EQP), and Personal Protective Equipment (PPE). In public projects, HK and WF were not only found at the top in implementation but also had a substantial impact on the regression models for three safety performance indicators: SB, SC, and CA. On the other hand, in private projects, PPE and WE significantly impacted the regression models. PPE was at the lowest position in implementation, and WE was at the second highest among all types of construction safety laws. The findings of this study could help project managers and contractors develop a strategy to ensure safety performance in public and private projects separately in terms of implementing safety laws.*

Keywords *- Construction Workers, Safety Laws, Empirical Evidence, Construction Projects, Construction Safety*.

1. Introduction

The construction industry is positively associated with a country's economic growth and employment (Dinabandhu & Debashis, 2018; Berardi, 2017). As for Bangladesh, the contribution of the construction sector to the country's GDP is around 8%, and almost 6% of the total working population is employed in this sector (Hossain & Ahmed, 2019; Ahmed et al., 2020). However, the construction sector is considered to be one of the most hazardous industries, and the workers are more prone to hazards (Aksorn & Hadikusumo, 2008; George & Renjith, 2022; Kalteh et al., 2021; Vashishta, 2021).

In Bangladesh, the construction sector is also confirmed as one of the top positions in respect of worker death (Hossain & Ahmed, 2018; Hoque et al., 2017). Workers Welfare Bangladesh reported that the number of deaths is not less than 120 per year on average (Safety&Rights, 2021). Legislation, which is one of the factors of critical success in terms of ensuring construction safety, was considered by Rey-Becerra et al. (2021), Rantsatsi et al. (2021), Raheem and Issa (2016) and Yu et al. (2014). Likewise, based on the Bangladeshi context, safety legislation is the key success factor in ensuring project safety performance (Hossain & Ahmed, 2019; Hoque et al., 2017; Ahmed et al., 2020). Construction safety laws are considered the essential precondition for construction safety that demands a minimum requirement of investment to assure maximum output with respect to safety (Buniya et al., 2021; Koh et al., 2022; Saunders et al., 2017; Jokkaw & Tongthong, 2016; Aminbakhsh et al., 2013). For Bangladesh, safety legislation is the key success factor to ensure safety performance (Mohammadi et al., 2018).

However, very few papers focus on the implementation status of the safety regulations sector-wise in Bangladesh. This is the most significant gap in analyzing the implementation status of safety regulations in Bangladesh. To meet the significant gaps in current research, this study is conducted to find out the gap in implementing the construction safety regulations and to develop a better scope to implement the safety regulations in both private and public sectors. Furthermore, there are a lot of potential questions that are addressed in the study:

- What is the status of the implementation of the construction safety regulations?
- How well do the project managers, project engineers, site engineers, and safety engineers implement the safety regulations on their sites?
- What is the correlation between the implementation status of the safety rules and regulations and safety performance?
- Is there any significant difference between implementing safety regulations and safety performance for the public sector and the private sector?

Most of the previous studies focused on measuring the safety performance of projects without acknowledging the challenge of implementing safety programs in public-owned and private projects. Moreover, several studies (Bizon-Gorecka & Gorecki, 2019; Kalteh et al., 2021; Ward & Mitchell, 2004) found that the project's nature, expected output, and resource allocation varied from project to project. To fill these gaps, the study aimed (1) to compare the implementation status of construction safety laws between public and private projects and (2) to investigate the relationship between the implementation status of construction safety laws and safety performance in public and private projects.

In this study, a survey was targeted to be conducted on a total of 172 respondents from both the public sector and the private sector. The respondents were the Project managers responsible for implementing the safety regulations on construction projects. Based on questionnaire surveys, the implementation status of the safety regulation was analyzed, and after these analyses, some correlations were established between the implementation status and safety performance.

2. Literature Review

In the literature review section, a brief discussion on public and private projects, legislation as a critical success factor in Bangladesh as comparing other developing countries, a discussion on the literature on differences in the implementation of construction laws between public and private projects and literature on indicators to measure construction safety performance, i.e. Safety Behavior (SB), Safety Condition (SC), and Client Acceptance (CA) of a project are discussed to get a literature background to carry the study. Finally, the construction safety laws in India, Bangladesh, and Vietnam were reviewed to select the areas of common safety concern in the safety regulations for these three countries.

The public and private sectors can be defined according to ownership, in which the public sector includes government-owned businesses and enterprises (Lienert, 2009; Bryson & Roering, 2018; Kumari & Pandey, 2011). Although these government-owned firms often act as clients in public construction projects, government agencies frequently play dual roles: clients and contractors (Lee et al., 2020; Noor et al., 2021). Contractors and subcontractors usually come from the private sector for both public and private projects (Gunduz & Abdi, 2020). Practicing value engineering in public projects includes time, cost, quality, and safety, whereas, in most private projects in developing countries, safety is not considered a project performance indicator (Faten Albtoush et al., 2011; Ingle & Mahesh, 2022; Omopariola et al., 2019).

In both projects, i.e., public and private, resource allocation is one of the critical success factors for implementing construction safety in developing countries. Nonetheless, resource allocation varies from project to project, influencing safety performance (Bizon-Gorecka & Gorecki, 2019; Ward & Mitchell, 2004). Several studies found that public projects are more flexible in allocating resources during budget preparation because of public interest (Omopariola et al., 2019; Lee et al., 2020). The owner's involvement is extremely important for ensuring safety performance; therefore, how the safety budget is utilized relies on the client's expectations and intentions (Huang & Hinze, 2006; Yu et al., 2014). Contractors assert that the project's success hinges on maximizing possible revenue with the least resources (Faten Albtoush et al., 2011; Ingle & Mahesh, 2022). Consequently, to ensure construction safety performance, contractors place a high priority on the owner's safety budget allocation. Safety regulations determine the basic investment requirement in safety programs (Saunders et al., 2017; Memon et al., 2013; Jokkaw & Tongthong, 2016). Therefore, safety laws are essential in establishing the fundamental requirement for a minimum safety investment. (Aminbakhsh et al., 2013; Jokkaw & Tongthong, 2016; Alkaissy et al., 2021; Saunders et al., 2017). Many researchers consider the implementation of safety legislation as one of the critical success factors for construction safety performance in different countries (Table 1).

According to Nadhim et al. (2018), safety performance indicates how safely a project is moving toward completion. As a result, it can be considered one of the key indicators of overall performance (Patel and Jha 2016). This is valid because safety performance refers to the actions or behaviors people demonstrate in practically all tasks to enhance health and safety (Nadhim et al., 2018).

Previous literature identified several construction safety performance methods and classified them into two categories: reactive approach (Hinze et al. 1995; Ng et al. 2005; Gunduz et al. 2017) and proactive approach (Jaselskis et al. 1996; Hinze and Godfrey 2003). The reactive approach is inversely proportionate to the number of accidents on the projects (Patel and Jha 2016). However, the objectives of the safety performance are to indicate current safety performance, to find out the changes in safety performance by changing safety policies, and to predict safety.

Table 1. Construction safety regulations in different developing countries

Countries	References	Descriptions
Malaysia	Yap and Lee (2020)	This study found that safety legislation is an influential factor, as well as personal protective equipment, working environment, working attitude, communication, and equipment maintenance for the Malaysian construction sector.
Thailand	Aksorn and Hadikusumo (2008)	This study analyzed the essential success variables affecting the effectiveness of the safety program in Thai construction projects and concluded that the implementation of construction safety laws is one of the most important aspects.
China	Tam, et al., (2004)	This study analyzed the risk-prone activities on construction sites, identified factors impacting construction site safety, and assessed the state of safety management in the Chinese construction industry. Here, enforcing construction safety regulations was considered as one of the critical success factors.
Egypt	Abd El-Razek, et al. (2008)	The study found that the severity of these causes of safety performance and delay varied depending on the type and size of projects. Here, implementing safety regulations was considered important in ensuring safety performance.
Cambodia	Durdyev, et al., (2017)	Using Cambodia as a case study, Durdyev et al. examined the key factors influencing construction safety performance in developing countries. Here, along with many other factors, legislation is considered to be one of the critical success factors for safety performance.
Bangladesh	Hossain and Ahmed, (2019)	This study discussed the implementation status of different safety regulations in the Bangladeshi construction sector.

Performance and potential hazards exist in the project to prevent manpower and economic loss (Hinze and Godfrey 2003; Ng et al. 2005). By understanding such predicted inputs, safety officers can assign limited resources very precisely and cost-effectively (Jaselskis et al. 1996). However, the reactive approach is not able to provide such type of information for quick intervention (Jaselskis et al. 1996; Hinze and Godfrey 2003). Therefore, researchers introduced proactive approaches such as near misses, job site inspections, behavior-based safety, and safety perception surveys to overcome these challenges in measuring safety performance.

The proactive approach is a unique evaluation method that may be used to assess the performance of safety measures at that point in time, for instance, workers' attitudes (i.e. unsafe acts), working conditions (i.e. unsafe conditions) and how client's responses (client acceptance) (Aksorn & Hadikusumo, 2008; Bhagwat et al., 2022). Therefore, using a proactive approach, management can build preventive measures by identifying factors likely to contribute to future accidents and receiving the necessary input.

Askorn and Hadikusumo (2008) and Bhagwat et al. (2022) considered three indicators of proactive approaches, namely, Safety Behavior (SB), Safety Condition (SC), and Client Acceptance (CA), to measure construction safety performance. Therefore, aligned with the previous studies, a proactive approach (SB, SC, and CA) was considered here in this study to measure the safety performance of the projects. Sukamani et al. (2021) and Li et al. (2018) found a positive correlation between critical success factors and workers' SB for construction projects.

Nevertheless, an employer's SB is also very important for successfully implementing safety programs (Zin & Ismail, 2012). Many researchers (Shin et al., 2014; Zhang et al., 2015; Türkmenoğlu, 2021) found that successful implementation of safety programs influenced the SC of the projects. Huang and Hinze (2006) and Zin and Ismail (2012) found that the owner's role was very critical for ensuring the safe performance of the projects. This means that implementing the safety programs largely depends on CA.

In this line, the study's findings show that a positive correlation between the implementation of construction safety laws and SB, SC, and CA is aligned with the previous studies. The cornerstone of legislative and administrative measures to improve occupational health and safety in Bangladesh is the Bangladesh National Building Code (BNBC), with the obligations most pertinent to workplace safety set out in Part 7. Part 7 of the BNBC contains four chapters dedicated to worker health, safety, and welfare. In this study, the existing safety laws and regulations related to the construction sector were reviewed from Bangladesh National Building Code 2020 (BNBC 2020) and Bangladesh Labor Act 2006 (BLA 2006), and 28 safety concern areas were extracted. These 28 safety concern areas are similar to the other two developing countries- India and Vietnam. The Building and Other Construction Workers Act, 1996 (BOCW) is the main regulation tool for worker safety in Indian construction sectors (Duddukuru & Hadikusumo, 2019).

Table 2. Similarities of some critical safety concerns in Construction Safety Laws in India, Vietnam, and Bangladesh

Safety Concern Area	Sources*		
	Bangladesh	**India**	**Vietnam**
Medical Screening	1	46	47
Electricity & Wiring	12 & 22	36	51 & 58
Making Safe Excavation to Prevent Earth Collapse	18	40	51 & 57
Safe Manual Loading and Unloading	5,7,11,33, & 34	43	51 & 57
Inspections of Joints in Scaffolding	23 & 27	41	48
Public Safety During Excavation Work	4,17 & 20	40	51
Measure to Prevent Fall	24 & 35	42	47 & 51
Aprons	15	42	47 & 51
Footwear	15	42	47 & 51
Safety Belt/Harness	15	42	47 & 51
Lifeline	5	42	47 & 51
Eye Protection	15	42	47 & 51
Respiratory Equipment	19	42	47 & 51
Hand & Skin Protection	14 & 15	42	47 & 51
Handling Flammable Materials	10	43 & 45	51
Routes free from Obstruction	6	36	51
Storage of Materials	6	43	51
Working with Asbestos	9	36	51
Safety Record Book	8 & 32	36	54
Removal of Waste	6	37 & 39	51
Drinking Water	16 & 28	36 & 44	56, 49 & 53
Sanitary Facilities	2, 16 & 29	36 & 44	50, 53 & 56
First Aid Facilities	1	36	53, 55 & 56
Lighting	3,15 & 31	36 & 44	54
Ventilation	18	44	52, 56 & 59
Guarding of Machinery	13	37	51
Lifting Materials Mechanically or Manually	21	37	51
Safe Load to Lifting Gear	5,25,26, & 27	38	47 & 57

*Note: * denotes that sources are listed in Appendix A*

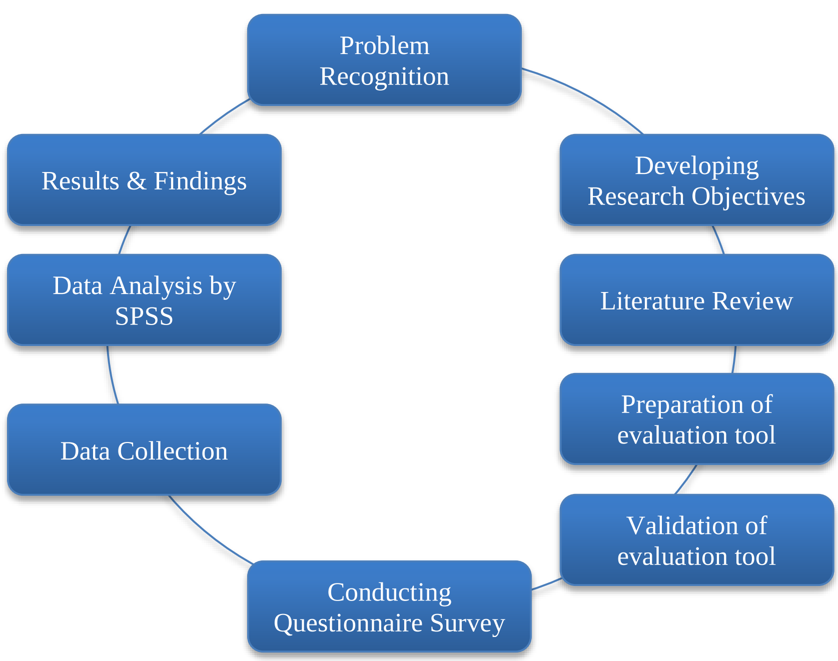

Fig. 1 Methodology framework for the study

In general, the regulations of Vietnam for workplace safety and occupational health are promulgated by different agencies (Pham et al., 2022). Similar 28 safety concern areas for India, Bangladesh, and Vietnam are listed in Table 2. It can be noted that India, Bangladesh, and Vietnam are all developing countries in South Asia that show similar characteristics in the construction sector.

3. Methodology

After a thorough literature review, 28 safety concern areas were extracted from Bangladesh's different safety laws and regulations. They were considered to conduct the survey and were considered as independent variables. These 28 safety concern areas were also reviewed by the expert panel. A set of structured questionnaires consisting of 40 questions was prepared to conduct the survey. The questionnaires were divided into three parts. In Part 1, the respondents' profiles and general information on the project were asked. Part 2 focused on how well the Project Managers (PMs) implemented the construction safety laws focusing on the extracted 28 safety concern areas in their sites on a five-point Likert scale where 1 = Very Poor, 2 = Poor, 3 = Neutral, 4 = Good, and 5 = Very Good. For example, PMs were asked how well they implemented the safety laws related to drinking water, sanitary facilities, or safe earth excavations. Part 3 tackled the results in terms of the safety performance indicators: (a) SB of the workers, (b) SC of the sites, and (c) CA of the projects on a five-point Likert scale where 1 = Very Poor, 2 = Poor, 3 = Neutral, 4 = Good, and 5 = Very Good. For instance, PMs were asked to score the SB of the workers, SC of the sites and CA of the projects as per their judgement. In this study, only building projects were considered to investigate the implementation of the construction safety laws and safety performance.

Prior to the carrying out of the survey, the evaluation criteria were checked in terms of content validity where 35 building safety experts who have work experience of more than 10 years in relevant fields provided their opinion using Lawshe’s (1975) equation. The number of panelists who "agreed" with each criterion from three options: 1) Agree, 2) Partially Agree, and 3) Disagree was calculated by combining their responses. The validity is checked mathematically by the following formulas,

$$CVR_i = \frac{N_e - \frac{N}{2}}{\frac{N}{2}};$$

Where CVR is the value of the ith measurement criterion.; Ne= Number of experts who indicated “agree” for an evaluation criterion.; N= Total number of experts on the panel.

Table 3. Respondents’ profile

		PM from the public sector		PM from the private sector		Total	
		Frequency	%	Frequency	%	Frequency	%
Age	Less than 35 years	6	6.97	5	5.81	11	6.39
	35–45 years	42	48.84	45	52.33	87	50.58
	Above 45 years	38	44.18	36	41.86	74	43.02
	Total	**86**	**100**	**86**	**100**	**172**	**100**
Educational Qualification	Diploma degree	15	17.44	35	40.70	50	29.07
	Bachelor’s degree	59	68.60	48	55.81	170	62.21
	Masters’ degree	12	13.95	3	3.49	15	8.72
	Total	**86**	**100**	**86**	**100**	**172**	**100**
Experience	<10 years	20	23.26	29	33.72	49	28.49
	10–15 years	26	30.23	40	46.51	66	38.37
	>15 years	40	46.51	17	19.77	57	33.14
	Total	**86**	**100**	**86**	**100**	**172**	**100**

Lawshe (1975) established minimum CVR values for different panel sizes based on a one-tailed test at ά = 0.05 significance level. This mandated that with a panel of 35 project managers, the minimum CVR value was 0.33. The tool did not include those evaluation criteria with minimum CVR values of less than 0.33. In total, 40 descriptive evaluation criteria for the 28 construction safety laws were derived and compiled into a preliminary questionnaire, which was then delivered to the panel of construction safety experts. This survey's objectives were to confirm that the specified criteria were appropriate and to gather suggestions for enhancements. This method of acquiring data seeks the opinion of safety professionals to confirm that the developed standards represent the real-world circumstances they are designed to gauge. The experts' suggestions were taken into consideration when the criteria were revised. The average CVR value for this study was 0. 77. A pilot test was conducted with five members of the group of target respondents for whom the questionaries were designed. The questions were too long, had several confusing phrases, took a long time to finish, and other issues were discovered during the pilot test, for instance. Following that, those issues were fixed, and the necessary modifications were made to ensure that the replies could comprehend all of the questions and instructions clearly.

In this study, the project was considered the research unit, and the respondents were PMs from both public and private projects. A total of 172 construction PMs participated in this research, representing 172 construction projects, where 86 projects were publicly owned and 86 were privately owned. The snowball sampling method was used here for the questionnaire survey. All the participants were well informed of the purpose and objectives of the study, and their consent was obtained to use their responses in this study. Table 3 presents the respondents' profiles. The obtained raw data were then analyzed using SPSS. Via factor analysis, the implementation of 28 construction safety regulation areas was grouped into fewer variables. A t-test was performed to determine the significance of differences in implementing safety laws between the public and private sectors. The analysis furthermore investigated the correlation between the implementation of the status of construction safety laws and the safety performance in public projects and private projects. Moreover, a multiple regression analysis was conducted to develop a model for the safety performance on implementing safety laws in public and private projects.

4. Data Analysis and Key Findings

4.1. Factor Analysis of Construction Safety Laws Implementation

Factor analysis is a statistical technique for reducing several variables into an easily workable and comprehendible number of variables (Aksorn & Hadikusumo, 2008). Nevertheless, before factor analysis, various tests were required to confirm eligibility for factor analysis.

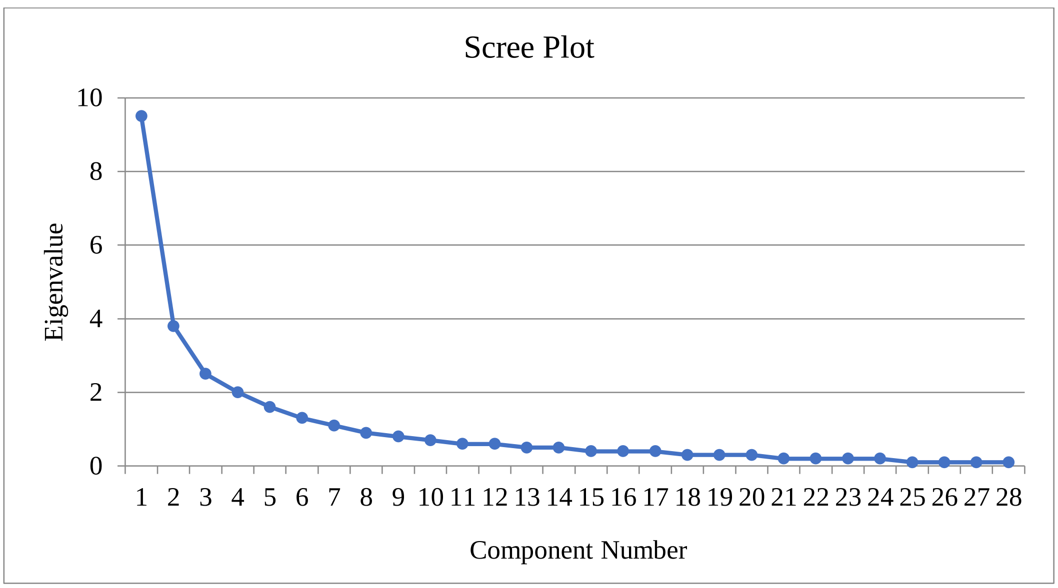

Fig. 2 Sree plot for Explanatory Factor Analysis (EFA)

In factor analysis, the strength of the relationship among the 28 safety regulation areas was measured using the correlation coefficient of each pair of factors.

Kaiser–Meyer–Olkin (KMO) and Bartlett's tests were performed first to check the data consistency. The value of Bartlett's test of sphericity was found to be 378, which indicates that the correlation matrix of the population was not an identity matrix (Hair et al., 1998; Aksorn & Hadikusumo, 2008). The p-value ($p = 0.001$) indicated that all variables had a significant correlation at the 5% level and were not required to remove any variable. The value of Kaiser–Meyer–Olkin's measure of sampling adequacy value (KMO = 0.782 > 0.5) indicated variables were intercorrelated strongly (Hair et al., 1998). Table 2 presents the factor grouping based on Varimax rotation. In this study, five components with an Eigenvalue greater than 1.0 were extracted, and each factor belongs to only one of the groups with a value of factor loading greater than 0.50. The factor analysis results lead to the categorization of the existing construction safety laws into five groups: Working Environment (WE), Personal Protective Equipment (PPE), Housekeeping (HK), Workers' Welfare (WF), and Equipment (EQP) shown in Table 3.

Table 3. Factor analysis

Category	Eigenvalue	% of variance	Interpreted component	Concerned areas related to safety laws	Factor loading
Category I	9.451	33.725	WE	Medical Screening	0.904
				Electricity & Wiring	0.893
				Making Safe Excavation to Prevent Earth Collapse	0.854
				Safe Manual Loading and Unloading	0.851
				Inspections of Joints in Scaffolding	0.803
				Public Safety During Excavation Work	0.733
				Measures to Prevent Falls	0.677
Category II	3.733	13.331	PPE	Aprons	0.900
				Footwear	0.847
				Safety Belt/Harness	0.816
				Lifeline	0.733
				Eye Protection	0.601
				Respiratory Equipment	0.540
				Hand & Skin Protection	0.454
Category III	2.737	8.474	HK	Handling Flammable Materials	0.784
				Routes free from Obstruction	0.770
				Storage of Materials	0.699
				Working with Asbestos	0.695
				Safety Record Book	0.627
				Removal of Waste	0.583
Category IV	1.966	7.023	WF	Drinking Water	0.781
				Sanitary Facilities	0.749
				First Aid Facilities	0.694
				Lighting	0.639
				Ventilation	0.568
Category V	1.566	5.594	Equipment (EQP)	Guarding of Machinery	0.829
				Lifting Materials Mechanically or Manually	0.806
				Safe Load to Lifting Gear	0.665

4.1.1. Category I: Working Environment (WE)

Safety laws related to medical screening of workers, electricity wiring, making safe excavation measures to prevent earth collapse, safe manual loading and unloading, inspections of materials and joints in scaffolding, and public safety during excavation work were grouped into this category. The factor analysis found that this category accounts for 33.76% of the variance in terms of WE-related construction safety laws. Zhang et al. (2015) and Wu et al. (2015) studied the impact of the WE on the safety performance of the sites. All these safety laws can be considered a component of the worker's working environment. These laws focus on good and safe work practices in construction project sites.

Table 4. Implementation status of the construction safety law

Implementation Status of Safety Laws	Public Projects		Private Projects		Sig (2 tailed)
	Mean	Rank	Mean	Rank	
Category I: WE	4.353	3	3.8420	2	0.000*
Category II: PPE	3.741	5	3.5530	5	0.000*
Category III: HK	4.526	1	3.7280	3	0.000*
Category IV: WF	4.443	2	3.8860	1	0.000*
Category V: EPQ	4.035	4	3.5750	4	0.000*

Note: * denotes that it is significant at a 95% confidence level.

4.1.2. Category II: Personal Protective Equipment (PPE)

This category consists of safety laws related to the apron, footwear, safety belt, lifeline, eye protection, respiratory equipment, and hand and skin protection, accounting for 13.33% of the variance in WE-related construction safety laws. All these safety laws can be regarded as the construction of personal protective types of equipment for the worker. Jokkaw and Tongthong (2016) and Hamid et al. (2008) found PPE to be a critical success factor in ensuring the safety performance of projects. These laws focus on good and safe work practices in construction project sites.

4.1.3. Category III: Housekeeping (HK)

Safety laws related to flammable materials, routes free from obstructions, storage of materials, working with asbestos, safety record books, and removal of waste account for 8.74% of the total variance among 28 safety concern areas related to construction safety laws. Zhang et al. (2015) studied site management and considered housekeeping as one of the critical factors for ensuring site safety. All these safety laws can be regarded as the construction of personal protective types of equipment for the workers. These laws are based on good and safe work practices in construction sites.

4.1.4. Category IV: Workers' Welfare (WF)

This category comprises safety laws related to drinking water, sanitary facilities, first aid facilities, lighting, and ventilation, accounting for 7.23% of the total variance among 28 safety concern areas related to construction safety laws.

Various studies (Hossain & Ahmed, 2019; Zin & Ismail, 2012; Shin et al., 2014) found that the factors related to the workers' welfare influence the safety performance of the sites. Hossain and Ahmed (2019) reported that the availability of first aid boxes, facilities for washing and bathing, toilet facilities, and a pure water supply were considered for measuring the safety performance of the sites. These laws focus on workers' safety and hygiene on construction project sites.

4.1.5. Category V: Equipment (EQP)

Safety laws related to guarding machinery, mechanical operations of lifting materials, and safe workload for lifting gears comprise this group. Shin et al. (2014) considered the factors related to the equipment to be influential factors for the SC of the sites. These laws focus on the safe operation of construction equipment on a construction project site.

4.2. Implementation Status of Construction Safety Laws in Public and Private Projects

To investigate the significance of the mean difference between the public and private sectors in terms of the implementation of construction safety laws, an independent sample *t*-test was conducted for each category of construction safety laws. Table 4 tabulates the detailed breakdown of the mean ranking from the PM's respondents. The mean differences were significant for all categories of safety laws, implying a better position for public projects than for private projects.

Implementation of construction safety laws related to HK (M= 4.526) was highly rated by PMs for public projects, whereas WF (M= 3.886) scored in the top position for private projects. Construction safety laws related to PPE scored the lowest mean value for both projects.

Table 5. Regression results for safety behavior on safety laws

Category		Safety Behavior (SB)					
		Public projects			Private projects		
		Unstandardized coeff. (B)	Standardized coeff. (β)	Ranking	Unstandardized coeff. (B)	Standardized coeff. (β)	Ranking
Category I	WE	0.120	0.167	4	0.108	0.278	2
Category II	PPE	0.2180	0.236	3	0.076	0.189	4
Category III	HK	0.333	0.344	1	0.161	0.371	1
Category IV	WF	0.288	0.313	2	0.078	0.211	3
Category V	EQP	-	-	-	-	-	
Constant		0.001			0.097		
Adjusted R^2		0.787			0.762		

Note: Hyphen (-) denotes that the relationship between dependent variables and independent variables is not significant

Public projects were more concerned about safety laws related to the handling of flammable materials, routes free from obstruction, storage of materials, removal of waste, working with asbestos, and safety record books, which are categorized as HK. In practice, sufficient resource allocation helps the public projects to implement the safety laws related to HK better than private projects.

The resource allocation varied from project to project, and many studies (Omopariola et al., 2019; Lee et al., 2020) concluded that due to the obligation of serving the public interest, resource allocation for public projects is more flexible during budget preparation than for private projects, Hence, the owner's role is very critical for ensuring safety performance, and utilization of the safety budget depends on the intention and requirements of the client side (Huang & Hinze, 2006; Yu et al., 2014).

On the other hand, construction safety laws related to WF, such as drinking water facilities for workers, sanitary facilities for workers, first aid facilities, and proper lighting and ventilation, were found in the top position on the list of implementing safety rules in private projects.

The fact is that the safety laws related to WF are well-known to project managers and easy to implement. Therefore, contractors from private projects are more concerned about implementing than other categories of construction safety laws in private projects.

Another interesting observation was found regarding implementing construction safety laws related to PPE. For both public and private projects, PPE-related construction safety laws were scored lowest by the PMs. Field observation confirms that contractors from developing countries like Bangladesh are reluctant to provide proper PPE to workers.

However, workers are not serious about using proper PPE even if provided with safety gear. Consequently, earlier studies (Aksorn & Hadikusumo, 2008; Hoque et al., 2017) may be employed to explain the study's finding that there was a difference between how construction safety laws were implemented in public and private projects.

4.3. Regression Model for Implementation of Construction Safety Laws and Safety Performance

The combined effects of several independent factors on one dependent variable can be modeled using the statistical technique known as multiple regression analysis. In this study, three safety performance indicators, SB, SC, and CA, were employed as dependent variables, and five construction safety laws were utilized as independent variables.

4.3.1. Discussion on SB

In this study, a model signifying the influence of the implementation of construction safety laws on SB for public projects can be expressed as SB = 0.001 + 0.333 [HK] + 0.288 [WF] + 0.218 [PPE] + 0.120 [WE] and SB = 0.097+ 0.161 [HK] + 0.108 [WE] + 0.078 [WF] + 0.076 [PPE] for private projects (Table 5). The model's R^2 value indicates that the regression is highly significant and that these four categories of building safety laws account for 78.70% and 76.20% of the variation in SB for public and private projects, respectively.

For both types of projects, the same groups of construction safety laws (HK, WF, PPE, and WE) contributed significantly to the regression model for SB. The results show that construction safety laws related to HK had the highest value of standardized regression coefficient (for public projects, $\beta = 0.344$ and private projects, $\beta = 0.371$) with a significance level of $p \leq 0.000$, implying that HK was the most influential contributor to SB for public projects and private projects. Zhang et al. (2015) considered housekeeping to be one of the critical factors for ensuring site safety. Furthermore, a positive correlation exists between critical success factors and workers' SB for construction projects (Sukamani et al., 2021).

Table 6. Regression results for client acceptance of safety laws

Category		**Client Acceptance (CA)**					
		Public projects			**Private projects**		
		Unstandardized coeff. (B)	Standardized coeff. (β)	Ranking	Unstandardized coeff. (B)	Standardized coeff. (β)	Ranking
Category I	WE	-	-	-	0.122	0.195	3
Category II	PPE	-	-	-	0.168	0.262	2
Category III	HK	0.323	0.342	2	-	-	-
Category IV	WF	0.461	0.514	1	-	-	-
Category V	EQP	-	-	-	0.150	0.294	1
Constant		0.220			1.493		
Adjusted R^2		0.716			0.655		

Note: Hyphen (-) denotes that the relationship between dependent variables and independent variables is not significant

Construction safety laws related to WF stand for a second position (β = 0.313) for public projects and a third position (β = 0.211) for private projects in forming a regression model for SB. Construction safety laws related to WF include drinking water, sanitary facilities, first aid facilities, lighting, and ventilation are grouped into this category. Several studies (Hossain & Ahmed, 2019; Zin & Ismail, 2012; Shin et al., 2014) found that the factors related to these types of workers' welfare influence the SB of the sites.

PPE showed a third position (β = 0.236) and a fourth position (β = 0.189) for public and private projects to the regression model for SB. Jokkaw and Tongthong (2016) and Hamid et al. (2008) found PPE to be a critical success factor in ensuring safety performance by influencing SB. Construction safety laws related to WE secured a fourth position (β = 0.167) and a second position (β = 0.189) for public and private projects to the regression model for SB.

This area includes safety legislation dealing with worker screening for health issues, electrical wiring, safe manual loading and unloading, inspecting scaffolding materials and joints, and public safety during excavation operations. Zhang et al. (2015) and Wu et al. (2015) studied the impact of the WE on the SB of the sites. Lastly, it can be concluded that for the regression model for SB, construction safety laws related to HK, WE, PPE, and WF contributed significantly to both public and private projects, and this significant relationship is aligned with the previous studies.

4.3.2. Discussion on SC

A regression model signifying the influence of the implementation of construction safety laws on SC for public projects can be expressed as SC = 0.097 + 0.324 [HK] + 0.284 [WF] + 0.207 [PPE] + 0.116 [WE] and SC = 2.035 + 0.151 [HK] + 0.098 [WE] + 0.102 [EQP] + 0.146 [PPE] for private projects (Table 6). The model's R^2 value indicates that the regression is highly significant and that these four categories of building safety laws account for 76.20% and 66.00% of the variation in SCs for public and private projects, respectively. For public projects, WE, PPE, HK, and WF contributed significantly to the regression model, and for private projects, WE, PPE, H, K, and EQP were found to be significant contributors to the regression model in terms of SCs.

The findings show that HK had the highest value of standardized regression coefficient (for public projects, β = 0.334 and private projects β = 0.363) with a significance level of $p \leq 0.000$, implying HK was the most influential contributor to SC for public projects and private projects.

Zhang et al. (2015) studied working conditions and considered housekeeping as one of the critical factors for ensuring site safety. WF was found in the second position (β = 0.312) for public projects but not significant for private projects in forming a regression model for SCs.

Several studies (Hossain & Ahmed, 2019; Raheem & Issa, 2016; Zhang et al., 2015) found that the factors related to the workers' welfare influence the SC of the sites. However, in some studies, WF-related factors were not considered the critical factor for SCs (Jokkaw & Tongthong, 2016; Durdyev et al., 2017). Safety performance, including SCs, depends on the owner's interest (Huang & Hinze, 2006).

The owner's interest (Huang & Hinze, 2006) can be applied to explain the difference in the relevance of WF for the contribution to the regression model for SC in public and private projects, considering that the two types of projects can be distinguished by ownership (Lienert, 2009; Bryson & Roering, 2018; Kumari & Pandey, 2011).

Table 7. Comparison of regression results between public and private projects

Category		**Public projects**			**Private projects**		
		SB	SC	CA	SB	SC	CA
Category I	WE	√	√		√	√	√
Category II	PPE	√	√		√	√	√
Category III	HK	√	√	√	√	√	
Category IV	WF	√	√	√	√		
Category V	EQP					√	√
Regression model		SB = 0.001 + 0.333 [HK] + 0.288 [WF] + 0.218 [PPE] + 0.120 [WE]	SC = 0.097 + 0.324 [HK] + 0.284 [WF] + 0.207 [PPE] + 0.116 [WE]	CA = 0.220 + 0.461 [WF] + 0.323 [HK]	SB = 0.097+ 0.161 [HK] + 0.108 [WE] + 0.078 [WF] + 0.076 [PPE]	SC = 2.035 + 0.151 [HK] + 0.098 [WE] + 0.102 [EQP] + 0.146 [PPE]	CA = 1.493 + 0.150 [EQP] + 0.168 [PPE] + 0.122 [WE]

Construction safety laws related to PPE showed a third position (β = 0.228) and a fourth position (β = 0.189) for public and private projects to the regression model for SCs. Jokkaw and Tongthong (2016) and Hamid et al. (2008) found PPE to be a critical success factor for ensuring safety performance by influencing SCs. Construction safety laws related to WE secured a fourth position (β = 0.164) and a second position (β = 0.277) for public and private projects to the regression model for SCs. Zhang et al. (2015) and Wu et al. (2015) studied the impact of the WE on the SB of the sites. Construction safety laws related to EQP did not contribute significantly to the regression model for SC in public projects, but it was in the third position (β = 0.254) for private projects. EQP included the construction safety laws related to guarding machinery, mechanical operations of lifting materials, and safe workload for lifting gears, which were grouped into this category.

Shin et al. (2014) found that the factors related to the equipment were considered influential factors in the SC of the sites. However, George and Renjith (2022) considered only human factors instead of factors related to EQP for SCs. Given that public projects and private projects are different in terms of ownership (Lienert, 2009; Bryson & Roering, 2018; Kumari & Pandey, 2011), the owner's interest (Huang & Hinze, 2006) can be considered to explain the differences in the consistency of EQP for the contribution to the regression model for SC in public and private projects.

4.3.3. Discussion on CA

A regression model signifying the influence of the implementation of construction safety laws on CA for public projects can be expressed by CA = 0.220 + 0.461 [WF] + 0.323 [HK] and CA = 1.493 + 0.150 [EQP] + 0.168 [PPE] + 0.122 [WE] for private projects (Table 7). The model's R^2 value indicates that the regression is highly significant and that these four categories of building safety laws account for 71.60% and 65.50% of the variation in CA for public and private projects, respectively. According to the findings, construction safety laws related to the WF (β = 0.514) and HK (β = 0.342) had the highest value of standardized regression coefficient with a significance level at $p \leq 0.000$, implying that WF and HK were the most influential contributors to CA for public projects but that HK and WF did not show significant for private projects. Nevertheless, in private projects, construction safety laws related to EQP, WE, and PPE were found to be significant in the regression model for CA. Safety performance largely depends on the owner's interest (Huang & Hinze., 2006; Saunders et al., 2017). However, the owner's expectation was found to be ambiguous related to the safety performance of the sites (Huang & Hinze, 2006; Türkmenoğlu, 2021). Türkmenoğlu (2021) showed that the role ambiguity of employees played a moderating role in the relationship between occupational safety and the safety performance of the sites. This could impact the inconsistent data from the study's respondents, which contributed entirely separate groupings of construction safety laws to the regression model for CA in both public and private projects.

4.3.4. Findings from the Bangladeshi Construction Projects

From the multiple regression analysis, the significant contribution of different categories of construction safety laws to the regression model of SB, SC, and CA was extracted for public and private projects.

The findings of the study are listed below:

i) This study discovered that PPE and WE significantly influenced the regression model for all three safety performance indicators (SB, SC, and CA) in private projects, whereas HK- and WF-related construction safety laws had a significant influence on public projects.
ii) In private projects, the implementation status of construction safety laws related to PPE was found to be in the lowest rank among all other construction safety laws. However, implementing construction safety laws related to WE was found to have a high score for private projects. Therefore, safety laws related to PPE should be taken seriously when implemented in private projects, as PPE significantly influences the regression model for safety performance indicators.
iii) In public projects, construction safety laws related to HK and WF not only secured the top two positions in implementing safety laws but also had a significant influence on the regression model for all safety performance indicators (SB, SC, and CA). Therefore, contractors should implement these two types of construction safety laws (HK and WF) to maintain the site's safety performance.
iv) Safety laws related to EQP (guarding types of machinery, lifting materials, and safe loads to lifting gears) did not significantly influence the regression model for any safety performance indicators in public projects. Moreover, the implementation status of the construction safety laws related to EQP secured the 4^{th} position among five categories for both public and private projects. The results indicate that PMs from public projects were inconsistent in implementing the safety laws related to EQP and scoring the safety performance indicators in terms of SB, SC, and CA. Therefore, PMs from all sectors should focus on the construction safety laws related to EQP to enhance the safety performance of the sites.

Hossain and Ahmed (2019) and Ahmed et al. (2020) considered workers' facilities for the safety performance of the sites in Bangladesh. Moreover, Hossain and Ahmed (2018) and Ahmed et al. (2020) found that the measures taken for good housekeeping influenced the safety performance of the Bangladeshi construction sites. Hossain and Ahmed (2019) reported that factors such as the presence of first aid kits, shower and bathroom facilities, sanitary facilities, and access to clean water were considered while evaluating the safety performance of Bangladeshi construction sites. Other studies (Tasnim et al., 2016; Tahmid, 2020) found that properly using PPE and taking measures for a good WE (Tasnim et al., 2016) contributed significantly to the occupational health and safety of the construction projects in Bangladesh.

The public projects and private projects can differ by ownership (Lienert, 2009; Bryson & Roering, 2018; Kumari & Pandey, 2011). Furthermore, the owner's interest is one of the critical success factors for ensuring a safe climate (Saunders et al., 2017). Therefore, the difference in the significance of different groups of construction safety laws to the contribution to the regression model between public and private projects can be explained by the owner's interest (Huang & Hinze, 2006) in safety performance. In Bangladesh, projects owned by the public and the private showed significant differences in terms of their procurement system, the scope of works, and the output of the projects (Alam & Ahmad, 2013; Shakeel, 2010). Various studies found that public projects are more flexible in allocating resources at the time of budget preparation due to the requirement of public interest (Omopariola et al., 2019; Lee et al., 2020). There may be some other reasons behind the differences in contributing different types of safety laws significantly to the safety performance in public and private projects. However, it requires further investigations and may be considered as the future scope of work for this study.

5. Conclusion

This study determines how well construction safety laws were implemented in public and private projects. After reviewing existing safety laws in BNBC 2020 and BLA 2006, a total of 28 construction safety concern areas were extracted. A factor analysis was conducted to categorize these 28 types of safety concern areas into five groups: WF, HK, WE, EQP, and PPE. This study of the significant mean difference in the implementation of construction safety regulations between the public and private projects confirmed that public projects were in a better position than private projects for all types of construction safety laws. In this study, the PMs confirmed a direct association between safety performance indicators (SB, SC, and CA) and the implementation of construction safety laws for both types of projects. Multiple regression analysis was done in this study to develop prediction models for these three safety performance indicators due to the influence of the implementation of construction safety laws. PPE and WE significantly impacted the regression model for all three safety performance indicators (SB, SC, and CA) in private projects, but HK and WF-related construction safety rules significantly influenced the regression model in public projects. Although PPE-related construction safety laws were found to be the least implemented among all construction safety laws in private projects, they significantly impacted the regression model for safety performance indicators. As a result, PPE-related safety regulations should be strictly implemented in private projects. Construction safety regulations relating to HK and WF were shown to be implemented most effectively in public projects and to have a substantial impact on the regression model for all safety performance indicators (SB, SC, and CA). To preserve the safety performance of the sites, contractors should continue to execute these two types of construction safety legislation (HK and WF). In this study, the regression model showed that the safety performance indicators for public projects were not significantly influenced by EQP-related safety rules. Additionally, the EQP-related construction safety legislation's implementation status was poor for both public and private projects. Therefore, to improve the safety performance of the sites, PMs from all sectors should concentrate on the construction safety legislation related to EQP.

This study only focused on the existing implementation status of construction safety laws in public and private projects in Bangladesh. Factors behind the existing scenario were not investigated, which may be considered the future scope of work. Additionally, this study may compare the implementation status of construction safety laws with those of other developing countries.

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Appendix A

List of construction safety laws in Bangladesh

1	BNBC- Part VII; Section 1.1.4	13	BNBC- Part VII; Section 3.10.4	25	BNBC- Part VII; Section 3.9.4
2	BNBC- Part VII; Section 1.4.3	14	BNBC- Part VII; Section 3.11.4	26	BNBC- Part VII; Section 3.9.5
3	BNBC- Part VII; Section 1.4.5	15	BNBC- Part VII; Section 3.2.1	27	BNBC- Part VII; Section 3.9.7
4	BNBC- Part VII; Section 1.7.1	16	BNBC- Part VII; Section 3.2.3	28	BLA 2006- Section 57
5	BNBC- Part VII; Section 1.7.10	17	BNBC- Part VII; Section 3.3.1	29	BLA 2006- Section 58
6	BNBC- Part VII; Section 2.1.1	18	BNBC- Part VII; Section 3.3.2	30	BLA 2006- Section 59
7	BNBC- Part VII; Section 2.1.2	19	BNBC- Part VII; Section 3.3.8	31	BLA-2006- Section 63
8	BNBC- Part VII; Section 2.1.4	20	BNBC- Part VII; Section 3.4.1	32	BLA 2006- Section 72
9	BNBC- Part VII; Section 2.2.5.1	21	BNBC- Part VII; Section 3.5.6.1	33	BLA 2006- Section 74
10	BNBC- Part VII; Section 2.2.5.3	22	BNBC- Part VII; Section 3.5.6.3	34	BLA 2006- Section 89
11	BNBC- Part VII; Section 2.5.1	23	BNBC- Part VII; Section 3.8.1	35	BLA 2006- Section 90
12	BNBC- Part VII; Section 3.10.1	24	BNBC- Part VII; Section 3.9.1		

List of construction safety laws in India

36	BOCW Act Central Rules, 1998, Chapter VI	42	BOCW Act Central Rules, 1998, Chapter XVI
37	BOCW Act Central Rules, 1998, Chapter VII	43	BOCW Act Central Rules, 1998, Chapter XVIII
38	BOCW Act Central Rules, 1998, Chapter VIII	44	BOCW Act Central Rules, 1998, Chapter XXI
39	BOCW Act Central Rules, 1998, Chapter XII	45	BOCW Act Central Rules, 1998, Chapter XXII
40	BOCW Act Central Rules, 1998, Chapter XIII	46	BOCW Act Central Rules, 1998, Chapter XXIV
41	BOCW Act Central Rules, 1998, Chapter XIX		

List of construction safety laws in Vietnam

47	Circular No. 010/1998/TT BLDTBXH (Ministry of Labor, Invalids and Social Affairs)	54	Joint Circular No. 01/2011/TT-BLDTBXH – BYT (Ministry of Construction)
48	Circular No. 019/2011/TT-BYT (Ministry of Construction)	55	Joint Circular No. 01/2011/TT-BLDTBXH – BYT (Ministry of Labor, Invalids and Social Affairs and Ministry of Health)
49	Circular No. 037/2005/TT-BLDTBXH (Ministry of Labor, Invalids and Social Affairs)	56	Labor Law No.010/2012/QH13 (National Assembly)
50	Circular No. 038/2005/TT-BLDTBXH (Ministry of Labor, Invalids and Social Affairs)	57	TCVN 05308-91 (Technical norms for safety in construction); (Ministry of Construction)
51	Circular No. 22/2010/TT-BXD (Ministry of Construction)	58	TCVN 3146-1986, (Technical norms for safety in construction); (Ministry of Construction)
52	Circular No. 37/2005/TT-BLDTBXH (Ministry of Labor, Invalids and Social Affairs)	59	TCVN 3288-1979 (Technical norms for safety in construction); (Ministry of Construction)
53	Decision No. 03733/2002/QD-BYT (Ministry of Health)		