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Assessing the Key Construction Safety Challenges in Sri Lanka: A Survey-Based Study

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Abstract: The construction industry is a key driver of economic development in a developing country like Sri Lanka. However, many construction projects still face serious safety challenge areas such as poor attitude, bad conduct, negligence, out-of-date legislation, a lack of qualified safety officers and financial constraints. This study aims to determine which safety challenges are the key ones in the Sri Lankan construction industry and how these challenges are classified and related to each other. The significance of this research is that it identifies the most important safety challenge areas and addresses them, which helps to overcome other safety challenge areas that rely on them. To achieve this aim, survey questionnaires were developed, and a survey was conducted among key project stakeholders, including safety officers, engineers, managers, quantity surveyors and human resources personnel, to collect information on significant safety factors that can help in improving safety. Forty-three safety challenge elements were identified and assessed through factor analysis. The ten most significant safety challenge elements were extracted and categorised into two main categories: (i) economy-related and (ii) human-resource-related challenges. The results of this survey provide a very good foundation for project managers or safety managers to identify certain criteria when selecting construction staff and making project plans.

Keywords: construction safety; safety challenges; safety management; Sri Lanka

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1. Introduction

The construction industry faces many challenges globally, including rising levels of material costs, poor productivity, labour shortages and on-site safety issues. Furthermore, construction working environments have many risks, such as moving heavy objects, working at heights and the use of electricity. Construction sites operating in developing countries, like Sri Lanka, have unique challenges, such as a lack of resources, institutional weaknesses and socio-economic stress, not being able to address key issues such as safety procedures and practices, which are crucial for the well-being of construction workers [1].

De Silva et al. [2] stated that the construction industry plays a pivotal role in the economic and physical development of Sri Lanka, and it is placed 7th among 13 major sectors, contributing 6.2 per cent to the country's GDP in 2020. The construction sector in Sri Lanka

provides employment to over 600,000 people, which is over 7% of the active workforce [3]. In Sri Lanka, the Industrial Safety Division of the Labour Department receives reports of between 2500 and 3000 accidents per year. Of those, between 40% and 60% of the accidents resulted in death, with the construction industry accounting for 30% of them [4,5].

As the construction industry in Sri Lanka faces various challenges related to safety, it is important to investigate what factors contribute to this poor safety record. The research aim of this study is to examine the dominant safety challenge areas responsible for the current state of safety in the Sri Lankan building construction industry and the most significant safety challenge element within each of the key safety challenge areas discussed in this study. The significance of this study is that it addresses major safety challenge areas and elements to improve worker safety in the building construction sector. A quantitative research method with statistical analysis is adopted to achieve this aim. Finally, recommendations are provided to overcome those challenges.

Safety standards have been around for a long time and are a very critical issue in the Sri Lankan construction industry. De Silva [6] identified various safety issues in the Sri Lankan construction industry, including budget, use of tools and chemicals, a lack of safety management, staff behaviour, etc. A lack of training, unsafe behaviour, and attitude towards safety were identified as other challenges [7]. Islam [8] has suggested employing safety officers on-site, while Snook [9] has noted this practice could help sites with safety, as a health and safety officer (HSO) will plan for site safety by identifying and assessing safety risks and implementing safety controls to prevent accidents, while providing safety advice to the staff.

The global literature has been reviewed to identify safety challenge areas present in the construction industry as shown in Figure 1. Some of them include falls from heights, becoming caught between objects, being struck by objects and being electrocuted [10]. Safety challenge areas unique to Sri Lanka include a lack of funds, a lack of attention to safety, poor commitment by stakeholders, a lack of training, the reluctance of workers to adopt health and safety measures, and unsafe acts or behaviour [11–13]. The main reasons why injuries and fatalities occur are the hiring of sub-contractors, operating within a poor safety culture, not following safety measures when working from heights and against falling objects, the inefficiency of safety rules, not having supportive management teams, and having staff with poor safety attitudes, behaviours and practices. The absence of safety officers, a reasonable safety budget and creative thinking increases the likelihood and impact of an accident.

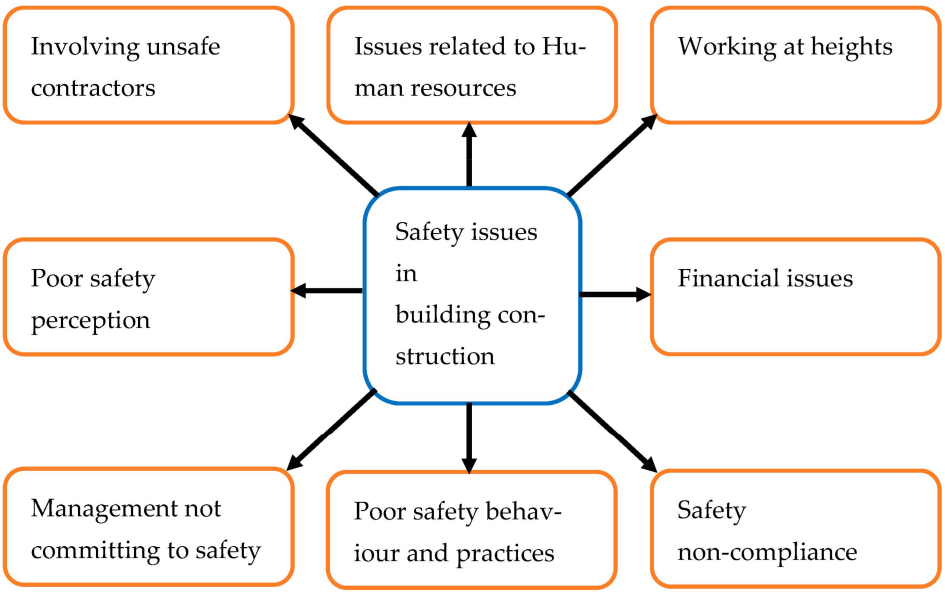

Figure 1. Safety issues.

1.1. Safety Officers

The lack of training facilities, low base salaries for HSOs, limited budgets for safety to hire HSOs, not providing incentives, restrictions for attending safety training, a lack of recognition and safety being a new concept in the Sri Lankan construction industry have contributed to a lack of qualified safety officers [6,14,15]. This lack of qualified safety officers in the Sri Lankan construction industry poses a significant challenge to ensuring workplace safety. Australia has taken measures to pay above-average salaries to safety officers [16], to encourage HSO roles.

However, in some firms, HSO activities are covered by technical engineering staff members. This poses a problem as no single staff member is solely responsible for safety. Setting up safety programs, enforcing safety and conducting safety inspections demand a role of a full-time safety officer. Technical staff may lack complete training to address all safety issues and are occupied with their own scheduled work [7]. Furthermore, some sites employ former tri-services officers to manage health and safety, after they obtain NIOSH Diploma, because in Sri Lanka, safety and security go hand-in-hand. This supports [13] assertion that appointing well-trained HSOs will enhance OSH responsibility, improve the ability to address unique site challenges and strengthen safety enforcement. Elevating HSOs within an organisation shows a commitment to safety [17].

The absence of qualified safety officers has serious implications for construction site safety. Guidance and monitoring of sites by safety officers help to prevent accidents [8]. In addition, having safety officers on board sends the message to staff that the firm takes safety seriously, increasing the likelihood of staff compliance with safety practices.

1.2. Budget

Debrah [18] emphasises that a safety budget allows construction firms to purchase quality materials, obtain safe equipment, implement safety measures and provide signage and notices to alert workers about potential hazards. Furthermore, safety programs can be implemented to help workers identify risks, work safely and take precautions against accidents. In contrast, a limited safety budget often results in compromised safety, as construction firms are unable to invest in essential safety measures [19,20]. The findings of a Stanford-based study by Levitt and Samuelson suggest that allocating 2.5% of direct labour costs towards safety is an effective approach [21].

In Australia, construction firms are required to abide by strict safety standards, which helps to minimise risks and enhance the quality of work. For example, the use of high-quality general-purpose cement reduces the likelihood of worker exposure to skin reactions and respiratory allergies, while also ensuring the structural integrity of buildings [22]. Furthermore, having standards plays a crucial role in safeguarding staff from using faulty or unsafe machinery and equipment [23]. This is achieved using tags and locks to prevent the use of such equipment, thereby minimising the risk of accidents and injuries. However, in Sri Lanka, the situation is different as staff often go ahead and use unsafe construction equipment due to the lack of safe workable equipment on sites, primarily attributed to strict budgets [6], which points to a significant disparity in safety practices.

De Silva [6] further highlights those contractors in Sri Lanka face challenges in accessing commercial borrowings at reasonable rates, with limited credit facilities and expensive short-term financing from local banks. This limited budget has constraints and has impacted operations in smaller firms, as evidenced by the absence of handrails around staircases during the construction phase. As a result, it is evident that budget constraints directly contribute to compromised safety standards on construction sites in Sri Lanka.

However, some firms have found ways to overcome these challenges by using cheaper yet quality alternatives and purchasing standardised components at a lower price while

still meeting safety requirements [6]. This approach allows them to keep construction costs down while ensuring compliance with safety standards. Nevertheless, it is important to note that these findings suggest a potential knowledge gap regarding the overall effectiveness and long-term implications of using cheaper alternatives to meet safety requirements in the construction industry in Sri Lanka.

Large-scale construction companies allocate budgets for safety, but the practice of bidding for lower tenders in some firms in Sri Lanka has led to minimal margins for safety in the budget [24–26]. This has created a situation where winning contracts does not necessarily translate to adequate spending on safety due to organisational politics aimed at retaining higher profits, because there is no condition on safety cost in the contract. The critical issue of budgets in Sri Lanka's construction industry has led to the cutting of corners, the use of cheaper or second-hand materials and a greater focus on profitability than safety [27].

The practice of allocating minimal budgets for safety and prioritising profitability over safety in construction companies has led to several concerning issues. For instance, speeding up tasks due to the cost of hiring cranes, machinery and equipment due to budget constraints has the potential to compromise safety [27]. Additionally, the lack of engagement of staff in safety training and not providing necessary safety resources and measures to staff are driven by a desire to save costs, further contributing to safety risks in construction projects. This is a significant concern as it has the potential to lead to an increase in construction accidents [28,29].

1.3. Rules

Not following safety rules, such as working without Personal Protective Equipment (PPE) and smoking on-site, can significantly impact the safety of the construction sites. This finding is supported by [30], which emphasises that following safety rules is essential to improve site safety and staff adherence to correct practices. However, Siriwardana and Wickramasinghe [11] argue that professionals working in the construction industry in Sri Lanka may not have been adequately taught safety in their university or technical college curriculum. This lack of formal safety education may contribute to non-compliance with safety rules among professionals in the industry.

In Malaysia, the Occupational Safety and Health Act (OSHA) 1994 provides a comprehensive safety framework with guidelines, regulations and legislation to ensure workplace safety [31]. However, in Sri Lanka, there have been challenges in enforcing safety regulations due to various issues, including a lack of funds and not having a national policy for construction safety and commitment [7]. For example, CIDA, the organisation that is responsible for regulating the construction industry in Sri Lanka, has not been able to commit to its obligation as required by Construction Development Act 2014, due to a lack of funds.

The National Institute of Occupational Safety and Health Act No. 38 of 2009 makes safety officers responsible for enforcing the Health and Safety at Work (HSW) act in Sri Lanka [32]. This is undertaken through conducting daily activities assisting the National Institute of Occupational Safety and Health in conducting their operations [6]. The Health and Safety at Work Act 1974 emphasises that organisations with more than five staff members need to have a written health and safety policy [6]. The Construction Industry Development Act No. 33 of 2014 has provisions to establish a National Advisory Council to advise on the protection and development of the construction industry. Although this Council is empowered under the Act, to form a national policy on construction that addresses concerns related to the construction industry [33], its absence presents a barrier for standardising safety rules.

International firms operating in Sri Lanka follow safety rules because of the sponsoring countries' safety culture. Furthermore, C1 (project size: AUD 2.96 million or above) and C2 (project size: AUD 1.48 to 2.96 million) construction firms in Sri Lanka [34] follow safety rules to maintain licensing, which implies that having sufficient budgets and enforcement of the law have an impact on these firms. Therefore, to encourage staff to follow safety rules in Sri Lanka, showing footage of past accidents, having safety discussions and having morning toolbox talks could be encouraged by management. This will help to establish a safety culture. In particular, when the main contractors enforce safety rules on subcontractors, staff in general feel obligated to follow safety rules [35].

1.4. Attitude

Melagoda [5] highlighted that when clients do not allocate enough funding for safety, it fosters a culture of neglect for safety that permeates through management teams, site engineers and technical staff, eventually affecting ordinary staff. This results in a diminished concern for safety, leading to the oversight of safety hazards and making the work site unsafe. Additionally, this behaviour can lead to dangerous acts such as throwing items without looking and refusing to wear PPE to maintain a macho image [36,37]. The cascade of poor safety attitudes can ultimately result in accidents and injuries.

In contrast, the research by Chen and Tian [38] demonstrated that safety leadership practices in Australia have helped in overcoming poor safety attitudes among staff. Furthermore, the implementation of Behaviour-Based Safety (BBS) methods in Europe and the US has shown promising results in improving safety-conscious behaviour among staff.

1.5. Behaviour

Lies [39] identified that the distracting behaviour associated with smart phone use among staff is a significant contributor to objects being dropped on staff and the occurrence of trips and falls. In addition, staff not asking for assistance from junior staff members is another problematic behaviour that can compromise safety in the workplace.

Rajini [40] also found that poor behaviours such as lack of safety focus, non-compliance with safety protocols, aggression, risk-taking and poor housekeeping further contribute to workplace hazards, which adds depth to the understanding of the range of behaviours that can compromise site safety.

1.6. Practices

Delia [41] emphasised poor site coordination and poor housekeeping as significant contributors to unsafe conditions on construction sites. Further, Dukpa [42] adds not wearing PPE and sites not being covered with safety nets as additional factors leading to poor safety practices. Moreover, Tableland [43] stresses that not emphasising safety practices during staff induction can lead to a lack of awareness of and adherence to safety protocols.

A study conducted in Sri Lanka identified several poor safety practices, including not using edge protection, poor safety management, poor housekeeping, and staff being overconfident and not wearing PPE. This aligns with the findings of the 2002 CIDA annual report, which stated that safety practices in Sri Lanka were below average [44]. However, Darshana [45] found that in large multi-national construction sites, safety compliance was observed among staff to avoid non-compliance fines.

In contrast to the identified poor safety practices, work practices have been established in certain countries to safeguard the well-being of construction site workers. For example, in Australia, safety building codes are strictly enforced, and companies involved in building work require design engineers and builders to undertake safety-in-design assessments throughout project stages to adhere to safety regulations. This indicates that effective safety measures and regulations can significantly improve safety practices on construction sites.

1.7. Management Commitment

Safety in the workplace is a critical concern for both employees and management. Zou [46] suggests that when management commits to safety, it encourages staff to prioritise safety over distractions such as phone usage and takes prompt steps to investigate accidents and near misses. This commitment also involves seeking input from staff members and holding them accountable for safety, contributing to the establishment of a safety culture.

However, Torres [47] highlights that the commitment to safety by management can be undermined when staff members are observed without proper PPE or engaging in risky activities. The act of playing with phones during work hours is not only a sign of management's lack of commitment to safety but also a warning sign that this behaviour may persist until a serious accident occurs [48]. Maliha [49] argues that such an approach is detrimental and ineffective in promoting workplace safety.

Furthermore, the study by Karunarathne [50] revealed that while toolbox talks and safety slogans can encourage staff to take accountability for their actions, they may not be effective if employees report to work under the influence of alcohol. In this case, management should send them home.

The poor management commitment to safety has been associated with the untidiness of work sites, staff being too relaxed about wearing PPE and non-attendance to safety training, resulting in unsafe work environments for workers with a poor safety culture [44]. Conversely, when there is a strong management commitment to safety, staff members become more conscious of their safety behaviour. This suggests that the behaviour of workers is directly influenced by the level of commitment to safety demonstrated by management.

Setting safety policies, maintaining good relationships with workers, having a safety representative and engaging in regular safety discussions have all been identified as effective strategies for achieving better safety performance [51]. These findings suggest that organisations can improve safety behaviour and outcomes by implementing specific organisational practices and policies that promote a strong commitment to safety.

OHS management practices have also been found to influence workers' health and safety behaviour in specific contexts, such as Sri Lanka, where major contractors like Maga and Sunkin demonstrate a strong commitment to safety [2]. This implies that the influence of management commitment to safety on worker behaviour may vary across different organisational contexts.

1.8. Fall and Objects Falling

Falls and objects falling on staff are common occurrences in the workplace, leading to work-related injuries and fatalities. These events are often due to a lack of mindfulness, carelessness, bad judgement, excess work pressure and inadequate safety training to identify and avoid hazards [52]. For example, staff members may climb ladders quickly due to carelessness, resulting in a fall because of misplacing their feet or not holding onto the ladder firmly.

Rameezdeen [53] identified that common places of falls include roofs, scaffolding and ladders. This is often attributed to the absence of working-at-height training, which prevents staff members from identifying hazards and taking necessary precautions [54]. Furthermore, Namian [55] recommended specific measures such as wearing safety harnesses and working on platforms when working above 1.5 m above the ground to prevent such falls.

In addition to falls, workers are often struck by objects due to improper stacking of items, incorrect usage of equipment, lack of mindfulness and the absence of safety measures such as barricades and safety nets [56]. This highlights the importance of proper storage and handling of items, as well as the need for staff to be mindful and adequately trained to recognise and mitigate potential hazards in the workplace.

1.9. Contractor Safety

The Institute for Construction Training and Development (CIDA) in Sri Lanka is responsible for grading contractors. However, it has been observed that safety records are not given due consideration, and the lowest bidder often wins contracts, even if they lack a strong safety record [18]. This oversight has led to lax safety practices, such as staff working without PPE, using poorly maintained equipment and inadequate safety protection at construction sites. The safety records of contractors are critical in ensuring a safe working environment in the construction industry. As a result of the CIDA incorporating safety records when grading contractors, contractors are likely to implement safety programs that can lead to improved safety culture by reducing casualties.

Small-scale construction projects often prioritise profit over safety, leading to inadequate safety programs and untrained staff. This results in poor safety records for construction firms, increasing the likelihood of accidents and casualties on-site. Additionally, hiring contractors with poor safety records further exacerbates safety risks, potentially leading to work delays and compensation payouts [57].

In contrast to this trend, reputable companies in Australia prioritise safety records when evaluating tenders to select builders. Contractors with good safety records are less likely to take shortcuts and more likely to use quality materials, which can contribute to methodical progress towards project completion [57]. This emphasis on safety records can potentially reduce the total number of accidents in the construction industry [58].

Table 1 shows a summary of the literature review indicating various authors discussing aspects of safety challenges in Sri Lanka. The survey was conducted with areas of safety challenges. For this study, we only consider and analyse nine safety challenge areas listed, SCA1 to SCA9, in Table 1.

Based on the above statements, lack of qualified safety officers, not enough budgets being allocated for safety, staff's poor attitudes, behaviours, not following safety rules, poor practices, management not committing to safety, the occurrence of falls, items falling on staff, unsafe contractors operating on-site and hazard exposure are issues currently taking place in Sri Lankan construction industry. Due to Sri Lanka still following Factories Ordinance 1942 [59] without a specific policy having been developed for the building construction industry, management not being able to impose safety measures is one of the reasons why safety challenges are not being addressed. Cost cutting and employing sub-contractors are also contributing to safety challenges [60,61].

This research deals with the Sri Lankan construction industry and looks at the safety challenges present there and their impact on construction.

Section 2 outlines the methodology, and Section 3 describes the results, followed by a discussion in Section 4 and finally the conclusion in Section 5.

Table 1. Safety challenge areas and respective literature.

Safety Challenge Areas in the Sri Lankan Construction Industry	Safety Challenge Elements	References
Limited HSO staff	Lack of safety training facilities	[6,7,9,13–15,17,60]
	Low base salaries for HSO employees	
	Limited budget allocations for HSOs	
	Poor incentives for HSOs	
	Staff not being able to take time off to pursue HSO training	
	Safety concepts not evolved in Sri Lanka	

Table 1. *Cont.*

Safety Challenge Areas in the Sri Lankan Construction Industry	Safety Challenge Elements	References
Financial issues	Construction projects are costly	[6,18–29]
	Not having financial resources to follow through with safe practices	
	Staff wearing cheaper, poor-quality PPE	
	Use unsafe construction equipment	
	Not implementing necessary safety programs due to cost	
	Condition of the contract not highlighting safety cost	
	Organisations interested in profitability over workers' safety	
Poor compliance	Poor safety enforcement	[7,11,30,31,33–35]
	Staff not having required safety knowledge, a barrier to following safety rules	
	Not having a national construction industry safety policy is a barrier to making staff accountable for following safety rules	
Poor safety perception	Wearing PPE does not help to maintain a macho image	[4,36–38]
	Lack of safety considerations	
	Staff feel immune from accidents	
Poor behaviour	Key stakeholders not giving attention to safety	[39,40]
	Staff not following safety protocols	
	Staff engage in using mobile phones at work	
	Involved in risky work	
	Unwilling to take safety guidance from younger staff	
Poor practices	Not maintaining a tidy workplace	[41,42,44,45]
	Undertaking poor safety practices	
	Ignoring safe practices by taking shortcuts	
	Ignoring safety by being overconfident	
Poor safety commitment of managers	Not creating a safety culture	[2,44,46–51]
	Managers not discouraging mobile phone use by staff	
	Managers not taking precautions against accidents	
	Managers react only after an accident	
	Not taking staff input to improve safety	
	Not encouraging staff to be responsible for safety	
	Lack of urgency when encountering safety problems	
Falls and objects falling on staff	Not paying attention when working	[52–56]
	Poor judgement in work activities	
	Not fully engaging when working	
	Not fully aware of safe ways when working at heights	
	Strict deadlines contribute to staff not wearing suitable PPE and injure from falls or falling objects	
Hiring unsafe subcontractors	National body (CIDA) not considering safety records when grading contractors	[19,57,61]
	Contractors not providing their staff with safety programs	
	Lack of certified subcontractors	

2. Materials and Methods

The overall research process is presented in Figure 2. A literature review was conducted and discussed in the introduction section. From there, we identified the research methodology. We decided to conduct a quantitative, questionnaire-based survey approach while conducting a factor analysis and t-test data analysis to analyse the results. This process is discussed in the following sections.

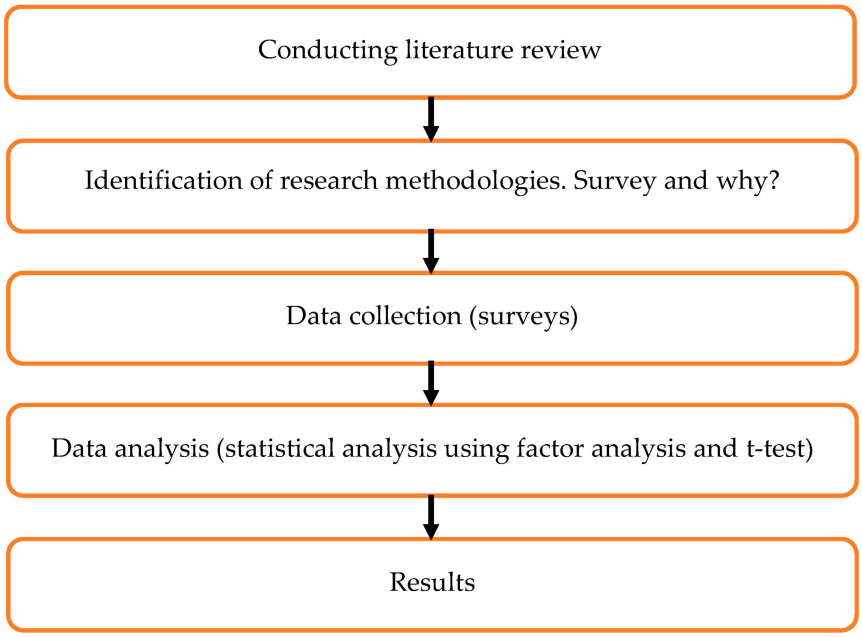

Figure 2. Research flow.

2.1. Research Methodology

2.1.1. Research Philosophy

This research seeks to identify key safety challenges facing the Sri Lankan construction industry and identify key contributors to the existing safety challenges. For this, the positivism (quantitative methodology) research philosophy is appropriate as it helps to generalise the findings.

2.1.2. Questionnaire Design and Questionnaire Survey

In order to identify the trends and relationships of safety factors from experts, a survey questionnaire method was used. This method agreed with the systematic review conducted by [62], where 49% of the studies in relation to construction safety were conducted using quantitative methodology, where statistical analysis was conducted on the findings of questionnaire surveys in most instances.

The survey was organised into two parts: (1) demographic questions and (2) rating the impact of safety challenges. Demographic questions consisted of profession, age, firm size, whether the participant received safety training, years in the construction industry and current job and was designed to help provide background information about the participants.

The Likert characteristic of having equal distance between successive item categories helped in assessing which safety areas were significant and helped to evaluate the contribution breakdown of each safety challenge to gather more insightful data for this study. The questionnaire content was designed to test common safety challenges that can impact the safety of workers in the Sri Lankan construction industry.

2.1.3. Categorisation of Major Challenges

The broader areas that safety challenges were grouped into in Table 1 helped to derive major safety challenges for the survey. Some of the challenges identified in the literature were relevant, and some were not. Forty-three safety challenge elements were selected from the literature to support the building of the survey, as these challenges were applicable in the Sri Lankan context. What was selected as relevant to Sri Lanka was tested when conducting the survey analysis. This helped to identify challenges that were important for Sri Lanka. To achieve this objective, the broader terms initially given to challenges and the major challenges from the literature review, which are listed in Table 1, were refined with more specific terminology, along with assigning an ID for each safety challenge area and element. This was how the survey was developed, with 43 safety challenge elements and their respective IDs and 9 major safety challenge areas and their respective IDs, as depicted in Table 2.

Table 2. Major challenges derived from challenges that were coded.

Safety Challenge Areas	Safety Challenge Elements
SCA1: Lack of qualified HSO	SCE1: Limited safety training facilities
	SCE2: HSO salaries not attractive
	SCE3: No budget allocations for HSOs
	SCE4: Not enough encouragement or incentives to become safety officers
	SCE5: Not given time off to attend safety training
	SCE6: Safety a new concept in Sri Lanka's construction industry
SCA2: Lack of budget for safety	SCE7: Cost is an issue
	SCE8: Not having resources to safely conduct work methods or practices
	SCE9: Staff works with poor-quality construction material
	SCE10: Due to lack of budget, unsafe construction equipment is used
	SCE11: Impacts on house safety programs
	SCE12: Conditions of the contract do not emphasise safety
	SCE13: Organisations interested in profitability rather than workers' safety
SCA3: Safety rules not being followed	SCE14: Poor enforcement of the regulations by the main contractor
	SCE15: Lack of knowledge, understanding, education and awareness of safety
	SCE16: The lack of safety policy for the construction industry in Sri Lanka makes it difficult to penalise safety violators
SCA4: Poor attitudes of staff	SCE17: Wearing PPE is weak
	SCE18: Lack of safety considerations by clients/site engineers/safety management and technical staff
	SCE19: Thinking accidents will not happen to them
SCA5: Behavioural issues of staff	SCE20: Contractors and project managers lack attention to safety
	SCE21: Staff not willingly complying with safety protocols
	SCE22: Staff using cell phones at work and not concentrating fully at work
	SCE23: Aggressive and risk-taking behaviours by staff
	SCE24: Staff not approaching experienced staff/supervisors when not sure of work activities
SCA6: Poor staff practices	SCE25: Poor site coordination
	SCE26: Below-average safety practices
	SCE27: Staff not likely to follow safety practices
	SCE28: Staff overconfidence given their experience

Table 2. *Cont.*

Safety Challenge Areas	Safety Challenge Elements
SCA7: Lack of management commitment to safety	SCE29: Management not committed to safety culture
	SCE30: Managers not discouraging the use of mobile phones by staff while on duty
	SCE31: Managers not looking into safety reports, investigating accidents and near misses and taking precautionary action
	SCE32: Managers not caring about safety if there is no accident
	SCE33: Management not encouraging staff opinions and suggestions to improve safety
	SCE34: Management not making staff accountable for their own safety
	SCE35: Management not acting quickly when confronted with safety problems
SCA8: Falls and objects falling on staff members	SCE36: Carelessness
	SCE37: Errors in judgement
	SCE38: Not being mindful
	SCE39: Needing more safety knowledge/training/practices
	SCE40: Workload pressure
SCA9: Poor safety records of construction contractors	SCE41: National body (CIDA) can incorporate safety requirements to grade contractors
	SCE42: Providing health and safety programs to make staff aware of safety
	SCE43: Good safety record enhances contractor reputation

2.1.4. Survey Instrument

The survey questionnaire was used to identify the research objectives. Perspective questions that helped participants express their personal views were used in this survey. Survey questionnaires aimed to collect structured data using closed questions. A five-point Likert scale ranging from 1 (disagree) to 5 (agree) was used in this study. Managers organise safety programs to provide safe environments at sites, engineers inspect hazards in buildings and machines and ensure sites adhere to building standards and codes, human resources personnel communicate safety policies at induction and organise safety training, safety officers coordinate health and safety systems, and quantity surveyors oversee all health and safety implications of cost management. This middle management knowledge was evaluated and explored in this study.

The literature review helped to identify safety challenges facing construction staff globally, and from there, safety challenges unique to Sri Lanka were identified. This study aimed to identify key safety challenges and significant elements. The survey questionnaire's Likert structure, along with the factor analysis and t-test data analysis method, provided this basis. Furthermore, the survey questionnaire method was cost-effective, practical and fast, which helped in the decision to choose it as the data collection method. This is followed by results, discussion and conclusion sections in this paper.

2.1.5. Sample Selection

Non-probability purposive sampling method was adopted in this study, where the sample was chosen from middle management staff working in the construction industry. This is because of their direct involvement in mitigating safety hazards affecting construction operations and their responsibility towards implementing strategies to continuously improve safety.

Roughly 125,923 staff work in the building construction industry in Sri Lanka [63]. Middle management (managers, engineers, architects, safety personal, surveyors, etc.) accounts for 4% [64], bringing the research population of this survey to 5037. These results, however, should be interpreted with caution, as they do not reflect the mean Sri Lankan construction values.

The minimum required sample size was calculated using a simple sampling method:

$$(n) \geqslant Z^2 p(1-p)/d^2$$

A sample of over 10,000, with a 95% confidence level, a margin of error of 14% and an expected probability of 50%, gives

$$(n) >= 49$$

For the required population size of 5037, the minimum sample size is, therefore,

$$\begin{aligned} Nspz &\geq n/(1+(n/spz)) \\ &\geq 49/(1+49/5037)) \\ &\geq 49, \end{aligned}$$

This simple sampling technique, based on the ability to scale down to decide on the expected minimum sample size from the population of interest, was suited for this study. Accordingly, 49 or more responses were needed. The number of surveys distributed to construction companies for completion was 51; all surveys were received back with a 100% response rate. No survey was discarded because all surveys were completed accurately without any of the participants declining on the day.

With a margin of error of less than 15% $\approx \frac{1}{\sqrt{(\text{Sample size})}}$ [65], having the benefit of the central limit theorem (sample size > 30) [66] and meeting the minimum sample size requirement to a 95% confidence level, having a sample size of 51 is justified according to statistical theory for a cost-effective study [67]. Furthermore, the exploratory factor analysis in the exploratory factor analysis (EFA) section agrees with the sample size as its Bartlett's test of sphericity value < 0.01 and passes the parallel analysis test.

This study included 64% engineers, 12% managers, 18% safety officers, 4% quantity surveyors and 2% human resources personnel.

Selecting diverse participants to represent middle management helped to gather reliable insights as it resulted in a good representation of the total population, further justifying the chosen sample.

2.1.6. Data Collection

Construction firms were contacted using the phone directory. We also walked into construction sites and obtained referrals from participants to obtain new participants. Participants filled out their survey questionnaires at their workplaces. Participants were asked to read the consent page before proceeding with completing the questionnaire.

Most participants were engineers and worked for large-size firms. Most of the participants were in the age group of 26–30 years and worked for 0–5 years in their current job. Most participants worked in the construction industry for a period of 0–5 years. Most participants had obtained safety training.

Demographic analysis was initially conducted to identify the characteristics or percentage of the participants based on being male or female, or the position they were working in. Participants from diverse backgrounds were chosen for this study to obtain a diverse response.

2.1.7. Data Analysis

Exploratory Factor Analysis (EFA)

Upon returning a Cronbach's alpha value of 0.64, the survey instrument successfully passed the reliability test. Moreover, the use of a Likert scale in the survey to measure variables on an interval facilitated the passing of the distribution test. Consequently, EFA was chosen for its statistical capability in reducing variables. Principle component

analysis with Varimax rotation was conducted. EFA reduced 43 safety challenge elements to 18 critical safety challenge elements that explain 83% of the variance.

Identifying the Main Safety Challenge Element for Each Safety Challenge Area

This section calculates the most significant safety challenge element in each safety challenge area. Addressing these elements helps to improve safety in general.

To assess the significance of all 43 challenges, a t-test was conducted. The null hypothesis H_o: $\mu = \mu_o$ was tested against the alternative hypothesis H_1: $\mu < \mu_o$, (μ_o is population mean). The rationale behind this is that μ_o is the critical rating above which an issue is agreeable or ineffective. μ_o was set to 3 for being the neutral value on a Likert scale from 1 to 5. The t-test helps to determine the statistical significance between a mean and population as shown in Equation (1) [68].

$$t = \frac{\text{difference between group means}}{\text{Variability of groups}}$$

$$t = \frac{(x_1 - x_2)}{\left(\sqrt{\left((S_1)^2/n_1 + (S_2)^2/n_2\right)}\right)} \quad (1)$$

To find the probability value associated with the t statistic, a 2-tail function with degrees of freedom was used in Equation (2) [69].

$$p\text{-Value} = \text{T.DIST.2T}\ (t, \text{degree of freedom}) \quad (2)$$

The results follow in Section 3.2.

Our survey results and analysis results are presented in the next section.

3. Results

3.1. EFA Results

For the purpose of factor analysis, it is necessary to select components that have an eigenvalue greater than 1. A combination of these components alone can represent all the components in the group [70]. In this instance, 83% of the total variance was represented by the top 18 critical safety challenge elements (Table 3); when viewing Table 2, they come from the following safety areas:

(1) Lack of qualified safety officers: When there are not enough training facilities, salaries for HSOs are not competitive, budgets are not allocated to hire safety officers, no incentives or time off is given for safety training and safety is a new concept. All of this contributes towards a shortage of HSOs.

(2) Lack of budget for safety: When construction costs require high budgets for safety, safety becomes compromised. As a result, staff will revert to unsafe work methods, use poor-quality materials, use unsafe equipment and not be involved in safety training. If safety budgets are included in the contract conditions, safety efforts cannot be compromised.

(3) Safety rules not followed: When the main contractor does not enforce safety, subcontractors become lenient, and staff may not necessarily follow safety rules. When there is no safety policy and penalties are not being imposed, staff can become out of line in their safety conduct.

(4) Poor attitudes by staff: When responsible staff (site engineers, project managers) do not emphasise the importance of safety, staff are likely to not wear PPE.

Table 3. Variance analysis.

Safety Challenge Elements	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
SCE1	13.516	20.479	20.479	13.516	20.479	20.479
SCE2	6.249	9.468	29.947	6.249	9.468	29.947
SCE3	5.191	7.865	37.813	5.191	7.865	37.813
SCE4	3.890	5.893	43.706	3.890	5.893	43.706
SCE5	3.174	4.809	48.516	3.174	4.809	48.516
SCE6	3.063	4.641	53.157	3.063	4.641	53.157
SCE7	2.450	3.712	56.869	2.450	3.712	56.869
SCE8	2.344	3.552	60.421	2.344	3.552	60.421
SCE9	2.183	3.307	63.728	2.183	3.307	63.728
SCE10	1.927	2.920	66.649	1.927	2.920	66.649
SCE11	1.801	2.729	69.377	1.801	2.729	69.377
SCE12	1.514	2.294	71.672	1.514	2.294	71.672
SCE13	1.440	2.183	73.854	1.440	2.183	73.854
SCE14	1.413	2.141	75.995	1.413	2.141	75.995
SCE15	1.348	2.043	78.038	1.348	2.043	78.038
SCE16	1.260	1.910	79.948	1.260	1.910	79.948
SCE17	1.150	1.742	81.690	1.150	1.742	81.690
SCE18	1.021	1.547	83.237	1.021	1.547	83.237

Out of 18 critical safety challenge elements, 10 extracted safety challenge elements contributed to almost 66.65% (>60%) (Table 3) of the variance and agree with the minimum acceptable size for this study. The top 10 safety challenge elements come from the first two safety challenge areas:(1) not having qualified safety officers and (2) a lack of budget for safety (Table 2). Contributory factors for these two safety challenge areas are explained as follows:

When there is a lack of training facilities, not paying a competitive base salary for HSOs, not allocating funds in the safety budget to employ HSOs, not giving incentives or encouragement from an employer or the government to encourage individuals to become HSOs, not giving staff leave to attend HSO training courses and safety not having evolved in Sri Lanka could all negatively impact the number of qualified HSOs available to work on construction sites.

Safety programs having to be implemented at a lower cost, not having the necessary tools to do the work, using poor-quality materials in construction work and not having safe equipment to work with all highlights that budgets allocated to safety are not enough.

3.2. Critical Challenges

The t-test and *p*-value results for 43 safety challenge elements are listed with safety challenge element IDs as shown in Table 4. From this, for each safety challenge area, the most significant safety challenge elements were identified using the *p*-value. For a safety challenge area, the safety challenge element that has the lowest *p*-value is the most significant. For example, if we look at the first major safety challenge area (not having enough qualified HSOs) from Table 2, it consists of safety challenge elements SC1, SC2, SC3, SC4, SC5 and SC 6. Among these, SC6 records the lowest *p*-value (0.09), as can be seen in Table 4; therefore, it is the most significant. This can be described as "safety being a new concept in Sri Lanka" contributing mainly towards the country's lack of safety officers.

Table 4. Safety challenge elements with corresponding mean, standard deviation, *t*-test and *p*-value results.

Safety Challenge Element	Mean	Sd.	T	*p* (Significance)
SCE1	3.53	1.45	1.55	0.13
SCE2	3.29	1.17	1.05	0.30
SCE3	3.22	1.41	0.66	0.51
SCE4	3.47	1.40	1.42	0.16
SCE5	2.96	1.18	0.14	0.88
SCE6	2.43	1.41	1.71	0.09
SCE7	3	1.41	0	1
SCE8	3.43	1.28	1.43	0.16
SCE9	2.78	1.26	−0.74	0.46
SCE10	3.08	1.34	0.25	0.80
SCE11	3.14	1.24	0.48	0.63
SCE12	3.31	1.30	1.01	0.32
SCE13	3.37	1.22	1.29	0.21
SCE14	3.02	1.27	0.07	0.95
SCE15	3.41	1.26	1.38	0.18
SCE16	3.27	1.37	0.84	0.41
SCE17	3.37	1.26	1.25	0.22
SCE18	3	1.28	0	1
SCE19	3.41	1.42	2.35	0.02
SCE20	3.23	1.41	1.35	0.18
SCE21	3.21	1.15	1.51	0.13
SCE22	3.41	1.30	2.56	0.01
SCE23	3.68	1.24	4.49	0.00
SCE24	3.27	1.06	2.10	0.04
SCE25	3.61	1.43	3.44	0.00
SCE26	3.55	1.23	3.62	0.00
SCE27	3.62	1.2	4.24	0.00
SCE28	3.84	1.37	4.96	0.00
SCE29	3.76	1.42	4.37	0.00
SCE30	3.03	1.31	0.24	0.80
SCE31	3.09	1.39	0.57	0.57
SCE32	2.74	1.31	1.56	0.12
SCE33	3.76	1.34	4.60	0.00
SCE34	3.62	1.28	3.98	0.00
SCE35	3.76	1.33	4.65	0.00
SCE36	3.88	1.46	4.90	0.00
SCE37	3.74	1.34	4.51	0.00
SCE38	3.78	1.35	4.69	0.00
SCE39	3.92	1.46	5.11	0.00
SCE40	3.41	1.39	2.40	0.02
SCE41	4.21	1.57	6.27	0.00
SCE42	4.17	1.52	6.27	0.00
SCE43	4.41	1.70	6.71	0.00

In the next section, we discuss the results.

4. Discussion

What do the results mean for the industry?

From Table 3, the top 10 safety challenge elements identified for the Sri Lankan construction industry can be observed, and they can be addressed by overcoming the major safety challenge areas of (1) not having enough qualified safety officers and (2) a lack of budget for safety. Addressing those two issues could significantly help to achieve safety in the construction industry in Sri Lanka.

This paragraph highlights the 10 main safety challenge elements (SCE 1–10) and their impact on the construction industry. Regarding SCE1, when there are limited training facilities, the number of safety officers joining the industry will be reduced. This leaves a vacancy for foreign safety officers to fill the safety officer roles. A lack of training facilities was identified as a key issue by De Silva et al. [5]. In relation to SCE2, when salaries are not competitive, only passionate staff become safety officers. Talented students or staff will pursue different careers. The significance of this safety challenge element, low salary for safety staff, was identified by De Silva et al. [5]. In relation to SCE3, when budgets have not been adequately allocated for safety, firms do not purchase quality PPE, erect barricades against objects falling or provide safety training to staff. All this contributes to an unsafe workplace. De Silva et al. [5] also identified the importance given to the safety budget. In relation to SCE4, long hours and inadequate pay concern safety professionals. When firms do not have accidents, paying a safety officer becomes an anomaly. Safety professionals obtaining 90% more than the average salary in Australia encourages people to try to become safety officers. Quirk [71] has also identified the importance given to encouraging staff to become qualified safety officers. In relation to SCE5, most staff members want to work within their locality, when incentives are not given to attend safety training in cities, new safety knowledge (standards, codes) is not transferred to remote parts of the country. This agrees with [72]. In relation to SCE6, because safety is a new concept in Sri Lanka, the importance of having a health and safety policy on-site is low [73]. Poor safety knowledge contributes to accidents and casualties in the industry. Leaders must develop a safety culture and pass it on from the kindergarten level. The significance of this safety challenge element, safety being a new concept in Sri Lanka, was identified by Mendis et al. [58]. In relation to SCE7, when construction costs are high, to maintain profits, safety budgets are reduced. Hadiwattege [74] agrees with this. In relation to SCE8, when budgets are insufficient, firms turn to more affordable methods rather than industry best practices (i.e., not wearing PPE, not taking measures to reduce heat/sunburn on staff). Similar significance was observed by Choudhry and Fang [20]. In relation to SCE9, when budgets for safety are inadequate, firms purchase poor-quality and cheaper construction material, causing, possible structural defects, re-work, and health and safety hazards. Staff working with poor construction materials was identified as a key issue by Dasandara and Dissanayake [75]. In relation to SCE10, when staff use unsafe equipment, accidents happen, productivity drops, and compensation claims go up. The significance of this safety challenge element, the use of unsafe construction equipment, was identified by Darshana [7].

Safety challenge area SCA1 has a significant safety challenge element, SCE6, namely safety being a new concept. For this reason, firms must implement a safety code of conduct and encourage staff to follow modern safety methods in their work practices. This agrees with studies conducted by Mendis et al. [60]. Safety challenge area SCA2 has a significant safety challenge element, SCE8. The impact of this on the industry is that activities take longer time, costing more labour hours, or can contribute to accidents by not being able to work with safe methods and practices, resulting in lost man hours, contributing to a loss of productivity. Similar significance was observed by [20]. Safety challenge area

SCA3 has a significant safety challenge element, SCE15. Its impact on the industry is that construction workers are likely to face accidents. This phenomenon of a lack of knowledge and understanding about safety impacting individuals following safety rules was also identified by [76]. Safety challenge area SCA4 has a significant safety challenge element, SCE19, which leads to staff working hastily and irresponsibly, causing accidents for themselves and others. Divirgilio [77] has also identified poor attitudes shown by staff thinking they are immune to accidents. Safety challenge area SCA5 has a significant safety challenge element, SCE23, that can lead to workplace violence, serious injuries or, in the worst case, fatalities. Risk-taking behaviour of staff that hinders workplace safety was identified by [78]. Safety challenge area SCA6 has a significant safety challenge element, SCE28, that can result in staff failing to follow directives from safety officers and violating the safe work code of conduct at work. Jones [79] agrees that overconfidence of staff leads to poor safety practices. Safety challenge area SCA7 has a significant safety challenge element, SCE33. In this way, management can gather firsthand safety problems construction staff encounter and implement ways to improve site safety. The significance of management seeking suggestions and worker opinions to improve site safety was agreed upon by [80]. Safety challenge area SCA8 has a significant safety challenge element, SCE39. As a result, employees will receive training such as working-at-height training, which helps staff learn safe work methods for working on platforms, wearing a safety harness and using scaffolding. Tezel et al. [81] agree with providing safety training to staff, especially when they will work at heights. Safety challenge area SCA9 has a significant safety challenge element, SCE43. This helps safety-conscious main contractors to engage subcontractors with a good safety record to reduce accidents on the job site since this allows them to keep safety certification and their reputation. Similar significance was observed by [61].

Factor analysis conducted by Durdyev et al. [82] in Cambodia revealed five key factors underlying the challenges facing the construction industry. They include management, organisation, resources, site management, cosmetics and workforce. This was different from research conducted by Shah and Ullah [72] with participants from the Indian subcontinent and the Middle East; their system dynamics analysis revealed a lack of PPE and innovative technology to be the main safety hazards. This could be because the top management and government in Cambodia have not been responsible enough for safety performance. To overcome this, top management must possess a safety attitude. Shah and Ullah [72] conducted research in poor and traditional countries that have warm climates; this can be a reason for the staff's lack of wearing PPE and reluctance to embrace advanced technology.

In the next section, we present the conclusion.

5. Conclusions

Based on the literature review, nine safety challenge areas affecting the Sri Lankan construction industry were identified. This research aimed to identify key safety challenge areas affecting the construction industry through a structured questionnaire administered in Colombo, Sri Lanka. The survey results were analysed using a t-test and a *p*-value to identify significant safety challenge elements that impact each of the safety challenge areas. Factor analysis was conducted to identify which major safety challenge areas were prominent. The reason for this is that by tackling and overcoming major safety challenge areas, other challenges that rely on them can be resolved.

From the results and analysis, the first safety challenge area impacting worker safety that was identified was the lack of enough qualified safety personnel. This was responsible for 53% of the variance in factor analysis. As a result, causes of accidents will not be investigated and safety operations on sites will not take place, along with there not being personnel to direct staff in the event of an emergency. The size of the firm gave a rough

estimate of the number of first aid officers, safety officers, safety supervisors and safety managers that could be employed on a site [8]. The elevation of safety officers to senior management, an emphasis on safety from the kindergarten level, the introduction of mandatory safety officer ratios on construction sites, the availability of HSO qualifications at more universities/technical institutes, and the provision of on-the-job training for aspiring safety officers to gain theory and practical skills will help to address this issue.

Insufficient safety budgets were the second identified safety concern area and were responsible for nearly 21% of the variance in factor analysis. Installing safety signage, recruiting safety officers, buying high-quality PPE, training employees, performing safety audits and other tasks are made easier with a sufficient safety budget. Ways to have a sufficient budget for safety include having safety cost allocation as part of the contract terms, including safety in the bill of quantities, and encouraging experts and safety officers to be involved when preparing the safety component of the contract budget. A mandatory portion of funds from each construction contract completed within Sri Lanka should be allocated to a construction fund that is independently administrated. This fund will then be used by current construction workers to increase their construction safety knowledge, especially for safety management. For this to work, a mandatory portion of funds should be allocated to regulate OHS within Sri Lanka by the country's OSH regulatory body, the Labour Department. Furthermore, the government should establish a committee that would mediate in construction projects to ensure the required funds are being allocated for safety in preliminaries. The top safety challenge element within each of the nine safety challenge areas has been identified and discussed.

The achievement of this study is to encourage a sufficient number of safety officers to be employed on construction sites and provide adequate funding for safety in project budgets. This aligns with the findings presented in [82] of having safety officers policing a construction site and rewarding actions that favour safety, even if they cost, to improve safety culture on the construction site. Thus, it can be said that the research aims have been met and that safety in Sri Lanka's construction industry is now receiving more attention. The findings of this study could be used when preparing a safety budget when planning for project costs and safely managing work sites in Sri Lanka. Safety officers, managers, HR personnel, site engineers and surveyors could benefit from this study. Neighbouring countries with similar characteristics and socio-economic conditions could also benefit from this study.

The time frame for data collection was only one month. Having more surveys completed could help to generalise the findings. All the selected participants were from the country's capital, Colombo.

Further research could be conducted to see how the percentage of safety officers present on-site, and the percentage of funding allocated to safety impact workplace safety in Sri Lanka's construction projects.

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