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Development and Evaluation of a Safety Performance Index for Building Construction in Kathmandu Valley, Nepal

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Abstract

Safety of the workforce is of utmost importance in the construction sector. This thesis, "Development and Evaluation of a Safety Performance Index for Building Construction in Kathmandu Valley, Nepal," sets out on a thorough journey to address issue of construction safety. The research's four main goals are to: identify the factors that affect building construction safety; rank these safety factors according to their relative importance; create a model to assess safety performance; and use this model to assess construction sites as a case study. The scope of this study includes all public and commercial building structures of the Kathmandu Valley in Nepal. It largely uses leading indicators, such as perception of workers, safety inspections, training, and meetings for health, safety, and the environment of organization for workers safety. The importance of this study rests in its commitment to providing worker safety and in its effort to evaluate the safety of workers in Nepal's building construction industry. It aims to determine how closely the industry complies with legal requirements and international standards by identifying and ranking elements that affect safety on building sites. The study is conducted in a systematic manner, starting with the development of research questions and objectives to conducting a literature review, creating questionnaires, and collecting data through surveys. A safety performance equation is subsequently developed using data analysis, including statistical analysis with SPSS and data visualization in MS Excel, based on the mean weightage of safety factors obtained from the literature research. The result of this research comprises a case study examining the safety performance of a building construction site in the Kathmandu Valley in order to have application of the safety performance model. The thesis is concluded with a thorough analysis of the findings and recommendations for improving safety in building construction projects in Nepal's Kathmandu Valley.

Keywords

leading indicators, safety performance, safety factors, mean weightage, safety performance model, equation

1. Introduction

Safety refers to the condition of being free from injury, danger, and situations that pose a threat to one's health [1]. It includes shielding against bodily injury, mental distress, societal hazards, technology risks, or any other kind of hardship. It also includes security and total well-being. In the context of this thesis, we explore the topic of construction safety, where our attention is drawn to the welfare, protection, and security of the people who make up the industry's core—the construction workers.

By its very nature, the construction industry is full of risks and dangers. The risks are diverse according to nature of construction industry. For instance construction of buildings, roadways, tunnels, airports, and hydropower facilities etc have their own set of safety issues and risks. Close examination and specialized solutions is needed to analyze this risk. Our research focuses primarily on addressing those safety issues affecting worker's safety during building construction. It involves rigorous literature review, expert consultations and survey to identify safety factors of building construction sectors.

Safety can be reduced to three main concepts: hazard control, risk mitigation, and harm prevention. In this context, building construction creates a variety of major dangers, such as those related to falls, injuries from things falling, and injuries from improper handling of materials, each of which poses specific risks to the safety of construction workers [2]. The dynamic environment of the Nepalese construction sector serves as a further reminder of the significance of this research. It employs a significant 13.8% of the population and is the fourth largest employment sector. Due to changing migratory patterns and the quickening development of urban areas, this industry is undergoing a transition. Its economic significance is highlighted by its significant GDP contribution to Nepal, which was a respectable 5.19% [3]. This expansion is, however, hampered by an unsettling spike in accidents and injury rates [4]. Additionally, the work Act's mandated 48 hours per weekare occasionally exceeded by work practices [5].

Sixty percent of nations development budget is spent in construction sector (FCAN) where large number of construction workers are involved. Curiously, there is no centralized organization to monitor, report, and audit safety issues of construction workers in Nepal. This thesis aims to understand safety issues and built a model to evaluate safety in building construction in a kathmandu valley; a small chunk in construction sector. The thesis also establishs a framework for assessing the safety performance index and recommend ways to improve safety on building construction sites through case study.

2. Literature Review

2.1 Labour and labour safety

The term "labor" describes the workforce or the people who are involved in a variety of jobs, from manual and skilled labor to intellectual and creative work. An essential component of economic activity, labor is essential to the creation of goods and services. Depending on the type of work, skill required, and other factors, there are various types of labor. The concept of "labor safety" (also referred to as "occupational safety") focuses on preventing work-related illnesses, injuries, and fatalities by making sure that workplaces are free from risks and hazards. It encourages workplace wellness and prevention of hazards that can cause injuries and disease in work settings to promote occupational health. In context of Nepal the body in Nepal mainly working in the field of occupational health is the Department of Labor and Occupational Safety under the Ministry of Labor, Employment, and Social Security. Its main objective is to provide a labor force for the national and international labor markets. Also maintain safety and a healthy working environment. The data represented by [4] in **Table 1** shows accidents in increasing trend however lesser accidents on 2015/16 and 2018/19 are due to economic blockade and COVID pandemic respectively.

Table 1: Accident Data

SN	Fiscal Year	Accidents (Minor, major and fatal)
1	2010/11	69
2	2011/12	39
3	2012/13	33
4	2013/14	36
5	2014/15	33
6	2015/16	28
7	2016/17	32
8	2017/18	51
9	2018/19	20
10	2019/20	53

Here in Nepal Constitution, Labour act and rules, the building act 2055, insurance act 2079, Departmental construction manuals issued by DOR, DUDBC are some legal documents to ensure safety in construction. Some institutions such as Public Procurement Monitoring Office also does implementation of labor safety measures through contract administration. Nepal red cross society (NRCS), Health and safety training in Nepal (NOSHA) are agencies working in Nepal for construction safety. Similarly, International Labor Organization (ILO), ISO 45001, OSHA (Occupational Safety and Health Administration) Standards, Construction safety standards and guidelines form the British Safety Council are international standards and implimentations for construction safety.

2.2 Safety Performance and measurement

Performance refers to the effectiveness and efficiency of the safety related goals and objectives in construction industry with respect to the health and safety of labor(worker)/ personnel having direct involvement at the construction site. It encompasses how well the safety measures, protocols are followed in the construction sites referred to building construction here in context of this research. Safety performance measurement is multifaceted. Measurement considers factors such as incident rates, near-miss reporting, compliance with safety regulations, safety training, and use of personal protective equipment (PPE) and many more.

Safety performance measurement is done through indexing of safety performance that means quantifying the level of safety performance at construction site for wellbeing and protection of mainly labor workforce. Workers are at high risk in construction site. May involve in dangerous acts such as fall from height, shock, etc. The index is a numeric value based on weightage of perception of factors that affects safety of personnel involved at construction site. Index measures status of safety incorporation at site. It considers the compliance of safety protocol, effectiveness of training program i.e. overall aspects of leading indicator [6]. The performance index provides a standardized way to evaluate safety performance, and comparing levels of safety performance across the construction sites.

Traditionally safety measurement is done through common safety metrics like Total Recordable Incident Rate (TRIR), Lost Time Incident Rate (LTIR), and Experience Modification Rate (EMR). This method is known as **leading indicator**. The indicators are reactive in nature that measures an organization's performance like the number and types of accidents occurred based on the information from past incidents and accidents such as reactionary analysis. Reactionary analysis studies number of fatalities, lost time incidents, frequency and severity of injuries[7].

Measurement of these data could be difficult because of poor data reporting and management system. Due to these limitations a more proactive and preventive measures could be used known as **lagging indicator**. The predictive measures used to assess safety performance uses observation record (perception and existing scenario), HSE meeting, HSE audits, HSE inspection and Training. It is used to create positive changes; leading indicator focuses on preventive actions that can help workers avoid accidents.

2.3 Factors affecting safety performance in Construction projects

From the literature review the factors that affects the safety performance for workers in building construction projects were validated and contextualized with relevance to the Nepalese construction industry with industry expert's help and categorized systematically through a thorough and comprehensive literature review from [8, 9, 10, 11, 12, 13]. The 6 categories/ major factors and 27 sub factors were identified. These factors are listed in **Table 2**.

3. Research Objective

- To identify factors affecting safety in building construction
- To prioritize safety factors based on their relative importance
- To develop a model to measure performance of safety in building construction
- To apply safety performance model to evaluate safety performance of construction sites as a case study

Table 2: Major Factors and Sub Factors

Major Factors	Sub Factors
Human Factor	Attitude and behavior towards safety Fatigue and stress Occupational Health and Hygiene Motivation Personal protective equipment (PPE) usage and compliance Training and safety programs for workers Worker skill and competence
Organizational Factor	Effective communication channels Improper staffing levels and workload distribution Incentive and safety budget Management commitment to safety Safety awareness Safety culture within the organization
Physical Factor	Defective equipment and tools Environmental Hazard Working Environment
Procedural Factor	Emergency response and evacuation plans Poor housekeeping and material handling Safe work practice and method Standard operating Procedure (SOP)
Regulatory Factor	Compliance with construction and safety regulations and standards Health and safety insurance Inspection and enforcement mechanisms Reporting and investigation of accidents and incidents
Technological Factor	Cautionary and warning systems Proper selection and use of construction machinery and equipment Site monitoring and surveillance technology

4. Research Methodology

- The first step is literature review to identify factors affecting safety in building construction and their relation with safety performance with respect to workers which is reinforced and validated with the help of Experts opinions and interviews.
- The second step is creating the sample and the questionnaire. The survey is primarily based on literature reviews and research studies from [14, 15] and [16], with the necessary modifications and contextualization relevant to the Nepalese construction industry scenario. It was done with the help of expert consultation. Prior to the actual field survey, the questionnaire underwent additional pre-testing (pilot survey) to ensure that the questions are not biased.
- The third step includes data collection through Structured questionnaire survey administered to different stakeholders involved in building construction projects and especially to contractors and workers who are directly involved in construction. The questionnaire was then coded and data analysis using Statistical Package for Social Science (SPSS) software and MS Excel, data visualization and analysis tool.
- After the analysis the safety performance equation is developed based on mean weightage of safety factors as discussed in literature review.
- The next phase includes application of model using a case study to evaluate safety performance of Building construction site in Kathmandu valley.
- And finally, the last phase includes interpretation and discussion of results with conclusion and recommendation.

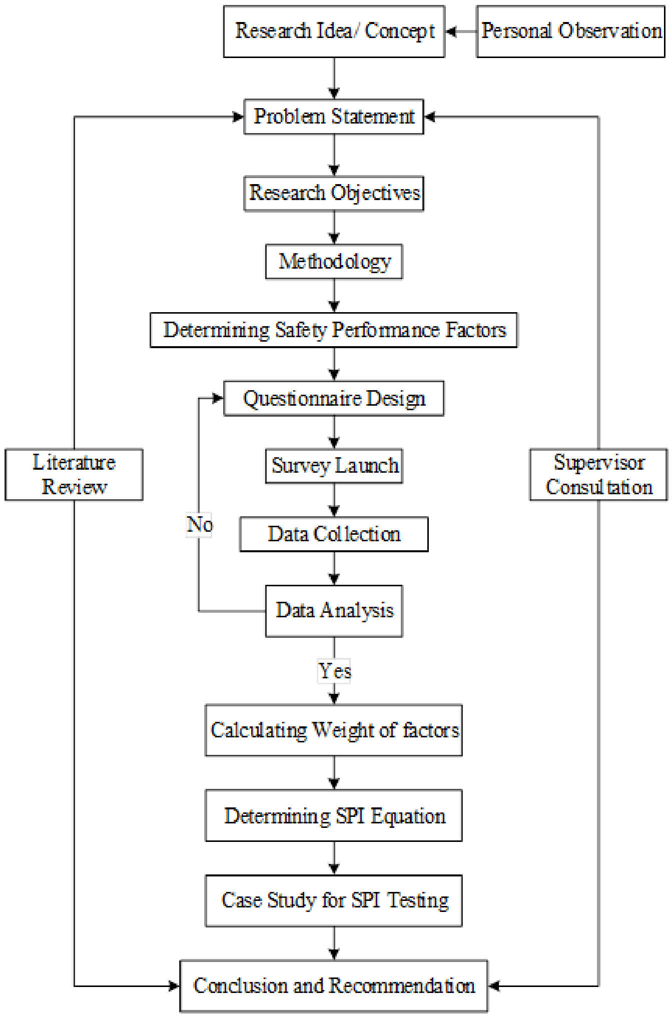

Figure 1: Research methodology

4.1 Study Population, Sample Selection and Sample Size

In this study, population means all the stakeholders of Building Construction sector. It includes Project manager, Client, Consultant, Worker, Supervisors, Safety Officials, Engineers from government and private sectors. The population here is infinite. Random sampling was done among diverse stakeholders to avoid biasness in data collection which is represented in graph figure 3. Also for the case study two projects from different sectors (private and public) is selected in a random manner.

Sample size determination is based on [17] formula. Assuming the population size is infinite From Cochran formula

$$n_0 = \frac{z^2 pq}{e^2}$$

Calculation: Here, for a 90% confidence level, $z = 1.64$, $e = 0.1$,

$p = 0.5$, and $q = 0.5$.

$$n_0 = \frac{1.64^2 \cdot 0.5 \cdot 0.5}{0.1^2} = 67.24 \quad \text{i.e., } 68$$

4.2 Research data collection

Primary and secondary methods were implemented for data collection. For this particular study, data is collected using a questionnaire survey administered through online forms and on-site data collection involving interviews. The questionnaire survey was administered in two phases. The first was for the formulation of safety performance equation. Later was done as a case study to evaluate the value of safety performance index (SPI) for the selected construction sites.

Study area was limited to Kathmandu valley with commercial and public building with area greater than 5000 sqft. Kathmandu valley is choosen for the research as it the the growing city in terms of building construction [13]. Major construction firms and labour work force is also involved here in Kathmandu valley. The case study has also been carried here in kathmandu valley for the ease data collection in limited time and resource. Also being central in location, the valley offers random sampling of population from every corners of the country.

4.3 Data Analysis and development of Safety Performance Index

Descriptive Statistics It is helpful in representing data in such a way that can be visualized through graphs, charts and tables. Demographic data here in this research has been analyzed through descriptive statistics.

Reliability Statistics Reliability or internal consistency of the survey data has been measured through Cronbach's alpha α. It uses statistics to determine consistency among the collected data of same characteristics [18]. Represented by alpha with the value between 0 and 1. Higher value indicates higher consistency among data. Value greater than 0.7 acceptable.

Relative importance index Analysis Relative importance can be used to Likert scale to assess the relative importance of different factors or variables. Based on this relative importance the variables here referred as safety factors can be ranked. The formula for Relative Importance Index (RII) is given as:

$$RII = \sum \frac{W}{AN}$$

where:

$$= \frac{1 \cdot n_1 + 2 \cdot n_2 + 3 \cdot n_3 + 4 \cdot n_4 + 5 \cdot n_5}{AN}$$

In this formula, n_1, n_2, n_3, n_4, and n_5 represent the number of respondents for very low, low, moderate, high, and very high levels of safety, respectively.

Formation of Safety Performance Index (SPI) Equation SPI is based on the weightage of mean for given safety factor. Mean is calculated for 5% trimmed data to eliminate outliers or extreme values. Outliers may skew the data so that five percent of data (extreme values) i.e. highest and lowest values are trimmed to compute trimmed mean which is more accurate than traditional mean [19].

Equations: Weight of Human Factor (W_H):

$$W_H = \frac{TM_H}{TTM} = \frac{TM_H}{TM_H + TM_O + TM_{Ph} + TM_{Pr} + TM_R + TM_T}$$

Weight of Organizational Factor (W_O):

$$W_O = \frac{TM_O}{TTM} = \frac{TM_O}{TM_H + TM_O + TM_{Ph} + TM_{Pr} + TM_R + TM_T}$$

Similar equations for other factors Physical factor (W_Ph), Procedural factor (W_Pr), Regulatory Factor (W_R) and Technological Factor (W_T).

Where: TTM: Total trimmed mean (5%) of all factor categories

TM_H, TM_O, TM_{Ph}, TM_{Pr}, TM_R, and TM_T represents five percent trimmed mean for Human, Organizational, Physical, Procedural, Regulatory, and Technological factors, respectively. The safety performance index is given by

$$SPI = W_H \cdot H + W_O \cdot O + W_{Ph} \cdot Ph + W_{Pr} \cdot Pr + W_R \cdot R + W_T \cdot T$$

Where, H, O, Ph, Pr, R, and T are compensative coefficients for their respective factors.

5. Result and Discussion

According to analysis followings are the results obtained:

Table 3: Survey Statistics

Total question sent	**92**
Online form	55
Physical form	37
Total response received	**85**
Contractor	24
Project Manager	5
Site Engineer	16
Supervisory Engineer	15
Worker	14
Other (Architects, Insurance Managers, Designers, Owners)	11
Response Rate	**92.39%**

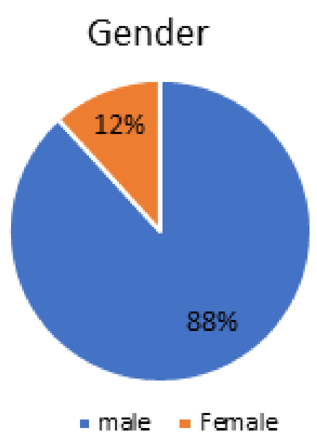

Figure 2: Gender

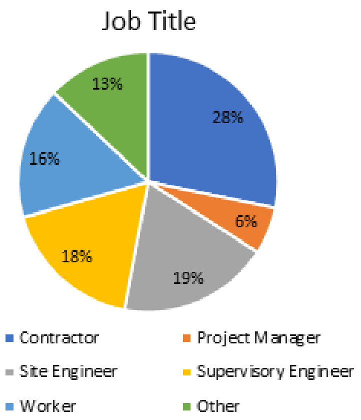

Figure 3: Job Title

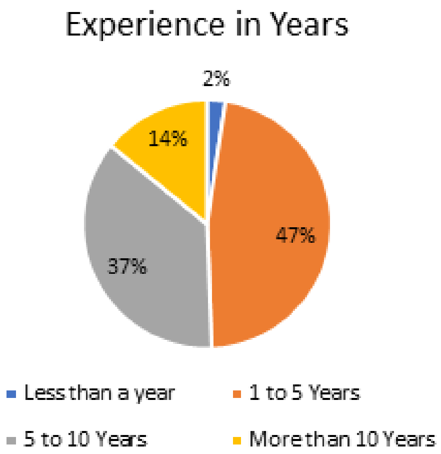

Figure 4: Experience

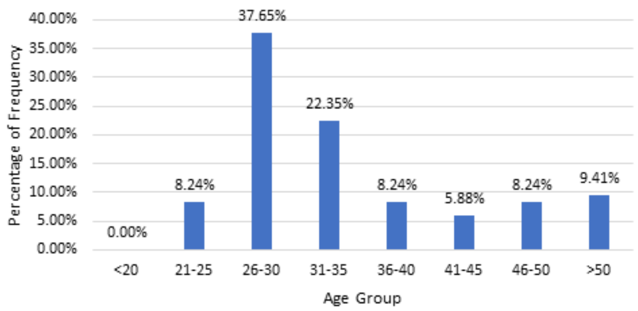

Figure 5: Age Distribution

Ranking of the factors are based on the relative importance index as discussed in Research methodology. Personal protective equipment (PPE) usage and compliance, Defective equipment and tools and Training and safety programs for workers ranks top three. Similarly, Environmental Hazard, Improper staffing levels and workload distribution and Motivation are least important factors compared to other factors.It is represented in table 4.

Reliability analysis: Cronbach's Alpha(α)=0.968 suggests data set has excellent reliability.

Human Factor(H) From, the table and chart above, it can be seen that seven factors under human category accounts for worker related safety factors whose sum is 1. Seven factors have their different weightage. Among the human categorical factor Personal protective equipment (PPE) usage and compliance ranks first and consequently Training and safety programs for workers and Worker skill and competence falls under second and third respectively. It utmost to case these factors to achieve safety with respect to human categorical factor.

Table 4: Human Factors Rankings

Code	Human Factors	Mean	Rank
H5	Personal protective equipment (PPE) usage and compliance	4.753	1
H6	Training and safety programs for workers	4.700	2
H7	Worker skill and competence	4.580	3
H2	Fatigue and stress	4.407	4
H1	Attitude and behavior towards safety	4.383	5
H3	Occupational Health and Hygiene	4.259	6
H4	Motivation	3.815	7

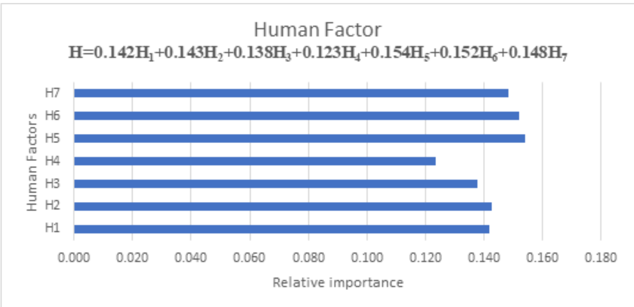

Figure 6: Research methodology

Organizational factor(O) From the table and chart above, it can be understood that Incentive and safety budget ranks first with safety awareness and management commitment to safety on second and third respectively. The value of organizational categorical factor can be evaluated from given equation above.

Table 5: Organizational Factors Rankings

Code	Organizational Factors	Mean	Rank
O3	Incentive and safety budget	4.488	1
O5	Safety awareness	4.444	2
O4	Management commitment to safety	4.420	3
O6	Safety culture within the organization	4.222	4
O1	Effective communication channels	4.099	5
O2	Improper staffing levels and workload distribution	3.975	6

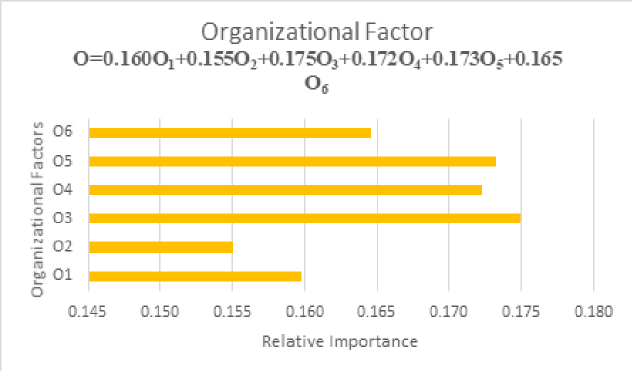

Figure 7: Research methodology

Physical Factor(Ph) From the Physical categorical factor chart and table above, it can be understood that Defective equipment and tools has highest importance followed by environmental hazard and working environment respectively.

Table 6: Physical Factors Rankings

Code	Physical Factors	Mean	Rank
PH1	Defective equipment and tools	4.704	1
PH3	Working Environment	4.296	2
PH2	Environmental Hazard	3.988	3

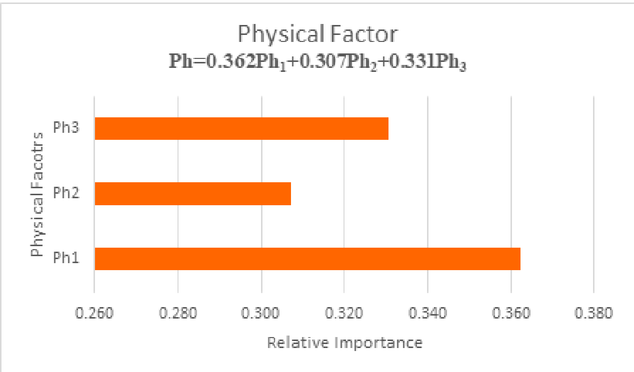

Figure 8: Research methodology

Procedural Factor (Pr) The table and chart above represent Procedural factors that affect safety performance with highest weightage on Safe work practice and method followed by other factor depicted by the equation above.

Table 7: Procedural Factors Rankings

Code	Procedural Factors	Mean	Rank
PR3	Safe work practice and method	4.617	1
PR1	Emergency response and evacuation plans	4.432	2
PR4	Standard operating Procedure (SOP)	4.284	3
PR2	Poor housekeeping and material handling	4.250	4

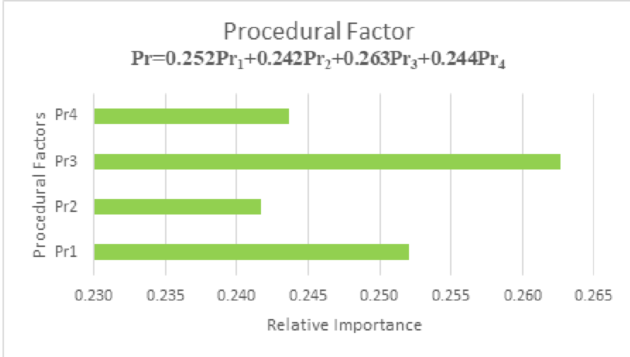

Figure 9: Research methodology

Regulatory Factor(R) From the data above in chart and table in can be concluded that Compliance with construction and safety regulations and standards ranks first under Regulatory categorical factor. While other have their weightage represented by the equation above in chart.

Table 8: Regulatory Factors Rankings

Code	Regulatory Factors	Mean	Rank
R1	Compliance with construction and safety regulations and standards	4.519	1
R3	Inspection and enforcement mechanisms	4.259	2
R2	Health and safety insurance	4.136	3
R4	Reporting and investigation of accidents and incidents	4.100	4

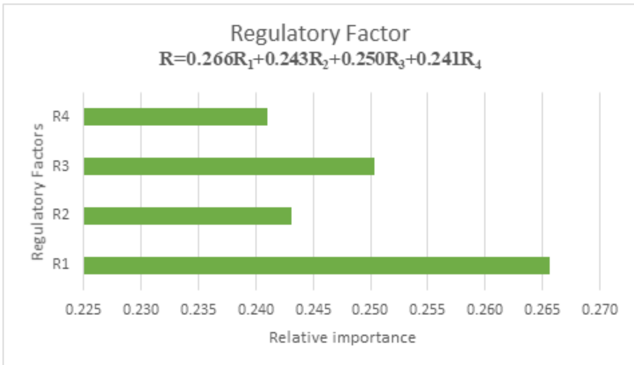

Figure 10: Research methodology

Technological Factor(T) From the above chart and graph it can be seen that cautionary and warning systems have most importance for Technological categorical factor for safety performance. While other factors also have their relative importance as shown in graph and equation.

Table 9: Technological Factors Rankings

Code	Technological Factors	Mean	Rank
T1	Cautionary and warning systems	4.556	1
T3	Site monitoring and surveillance technology	4.358	2
T2	Proper selection and use of construction machinery and equipment	4.284	3

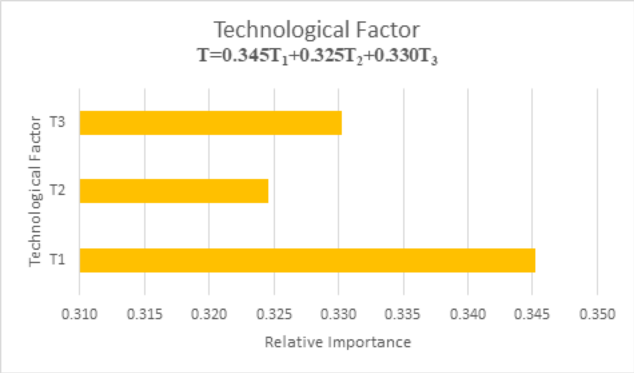

Figure 11: Research methodology

The SPI equation:

$$SPI = 0.169H + 0.164O + 0.166Ph + 0.169Pr + 0.163R + 0.169T \quad (1)$$

From the above result, it can be concluded that all six categories Human, Organizational, Physical, Procedural, Regulatory and Technological factors have significant impact according to the weightage as shown in equation above. These categorical variables in the equation also depends on subfactors as shown in equations and graphs above. Their consideration should be given to achieve safety at the construction site.

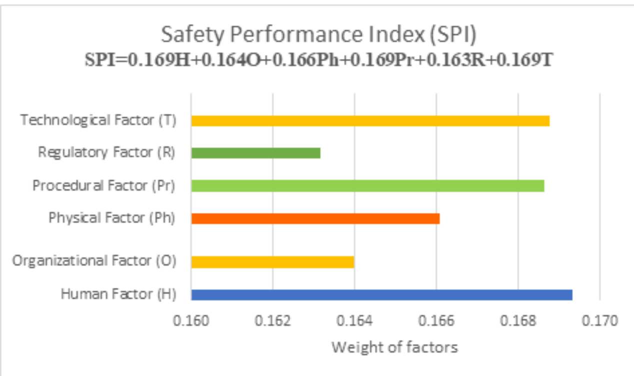

Figure 12: Research methodology

5.1 Case Study: Evaluating construction site safety

Compensation method in the equation Each Category (H, O, Ph, Pr, R, T) in Safety Performance Equation (SPI) can be evaluated from 0 to 1 according to its effects. The values and range that a factor receives is tabulated below. The evaluation score is based on the effect of factors and burrowed from literatures [16, 20] with expert opinion. Thus, the value of variable in the equation can be assessed from the tables below according to survey response in a case study.

Table 10: Evaluation Score

Factor	Yes	No
Personal protective equipment (PPE) usage and compliance (H5)	1	0
Improper staffing levels and workload distribution (O2)	1	0
Emergency response and evacuation plans (Pr1)	1	0
Standard operating Procedure (SOP) (Pr4)	1	0
Health and safety insurance (R2)	1	0
Cautionary and warning systems (T1)	1	0
Proper selection and use of construction machinery and equipment (T2)	1	0
Site monitoring and surveillance technology (T3)	1	0

Table 11: Evaluation Score

Factor	0	0.5	1
Motivation (H4)	Weak	Moderate	Excellent
Worker skill and competence (H7)	Weak	Moderate	Excellent
Incentive and safety budget (O3)	Never	In some projects	Always
Management commitment to safety (O4)	Weak	Moderate	Excellent
Safety culture within the organization (O6)	Weak	Moderate	Excellent
Working Environment (Ph3)	Weak	Moderate	Excellent
Poor housekeeping and material handling (Pr2)	Weak	Moderate	Excellent
Compliance with construction and safety regulations and standards (R1)	Do not follow	Sometimes	Always

Table 12: Evaluation Score

Factor	0	0.25	0.5	0.75	1
Attitude towards safety (H1)	Never	Sometimes	Often	Usually	Always
Fatigue and stress (H2)	Always	Usually	Often	Sometimes	No
Occupational Health and Hygiene (H3)	Very ineffective	Ineffective	Neutral	Effective	Very effective
Training and safety programs for workers (H6)	0	2	3	4	5
Effective communication channels (O1)	No	Annually	Monthly	Weekly	Daily
Safety awareness (O5)	No	Sometimes	Often	Usually	Always
Defective equipment and tools (Ph1)	Bad	Not Good Enough	Normal	Good enough	Good
Environmental Hazard (Ph2)	No	Sometimes	Often	Usually	Always
Safe work practice and method (Pr3)	No	Sometimes	Often	Usually	Always
Inspection and enforcement mechanisms (R3)	No	Sometimes	Often	Usually	Always
Reporting and investigation of accidents and incidents (R4)	No	Sometimes	Often	Usually	Always

5.1.1 Level of safety Performance

Based on the relevant literature for indexing of safety performance [2, 21, 16].

Table 13: Safety Performance Index (SPI) vs. Level of Safety Performance

SPI	0-20%	21-40%	41-60%	61-80%	81-100%
Level of Safety Performance	Extremely Unsafe	Unsafe	Moderately Unsafe	Safe	Extremely Safe

Evaluation of Safety performance Index (Case study)

The SPI equation developed is used to evaluate safety performance of two sites here in Kathmandu valley. Data required for calculation of SPI as required by SPI equation is carried using questionnaire survey. The survey involved questionnaire distributed to 25 practitioners for each project. The case study involved two projects; Project A: Construction of Multiplex Building Trade Tower (Private), Project B: Construction of New Building and Main Retrofitting works at Bhaktapur Hospital (Public) from Kathmandu and Bhaktapur respectively.

Data Analysis and Result The collected data were used to calculate compensation for SPI equation with the help of safety performance equation. First values of each major factors are worked out based on given equations and then Value of Safety performance index is calculated based on weightage of these major factors.
Equations:

$$H = 0.142H_1 + 0.143H_2 + 0.138H_3 + 0.123H_4 + 0.154H_5 + 0.152H_6 + 0.148H_7 \quad (2)$$

$$O = 0.160O_1 + 0.155O_2 + 0.175O_3 + 0.172O_4 + 0.173O_5 + 0.165O_6 \quad (3)$$

$$\text{Ph} = 0.362Ph_1 + 0.307Ph_2 + 0.331Ph_3 \quad (4)$$

$$Pr = 0.252Pr_1 + 0.242Pr_2 + 0.263Pr_3 + 0.244Pr_4 \quad (5)$$

$$R = 0.266R_1 + 0.243R_2 + 0.250R_3 + 0.241R_4 \quad (6)$$

$$T = 0.345T_1 + 0.325T_2 + 0.330T_3 \quad (7)$$

The symbols have meaning as discussed in previous sections. The equations (2), (3), (4), (5), (6), (7) are used to calculate value of categorical factors and Using the equation (1), We get the safety Performance index (SPI) Values for the project A and Project B as 65% and 70% respectively.

The model adopted is based from previously published paper and literature [16, 21, 20] that have been acknowledged and accepted. This model has been adopted to align with Nepalese context and conditions, obviating the need of further validation. In addition, a case study has also been developed to test safety performance index within our construction site.

Table 14: Sub Factors and Rankings

Code	Sub Factors	RII	Rank
H5	Personal protective equipment (PPE) usage and compliance	0.934	1
PH1	Defective equipment and tools	0.925	2
H6	Training and safety programs for workers	0.924	3
PR3	Safe work practice and method	0.911	4
H7	Worker skill and competence	0.901	5
T1	Cautionary and warning systems	0.899	6
R1	Compliance with construction and safety regulations and standards	0.889	7
O3	Incentive and safety budget	0.886	8
O5	Safety awareness	0.878	9
PR1	Emergency response and evacuation plans	0.878	9
O4	Management commitment to safety	0.873	11
H2	Fatigue and stress	0.868	12
H1	Attitude and behavior towards safety	0.864	13
T3	Site monitoring and surveillance technology	0.861	14
PH3	Working Environment	0.847	15
PR4	Standard operating Procedure (SOP)	0.847	15
T2	Proper selection and use of construction machinery and equipment	0.847	15
PR2	Poor housekeeping and material handling	0.843	18
H3	Occupational Health and Hygiene	0.840	19
R3	Inspection and enforcement mechanisms	0.840	19
O6	Safety culture within the organization	0.838	21
R2	Health and safety insurance	0.816	22
O1	Effective communication channels	0.814	23
R4	Reporting and investigation of accidents and incidents	0.812	24
PH2	Environmental Hazard	0.791	25
O2	Improper staffing levels and workload distribution	0.788	26
H4	Motivation	0.755	27

5.2 Limitations

The scope of this research encompasses a specific geographical area, namely Kathmandu valley. Results are applicable to kathmandu valley but not all types of building construction. It is applicable to only public and commercial building. It excludes residential small-scale buildings because their owners may not prioritize safety considerations. Additionally, they are reluctant to allocate a safety budget. Further the residential building have different nature of safety issues which should be dealt separately. Further, future research should explore lagging indicators like accident analysis. It is also recommended to incorporating financial analysis for safety evaluation.

6. Conclusion and Recommendation

This research developed a safety performance index (SPI) model for building construction in Kathmandu Valley, Nepal, by identifying and prioritizing the safety factors. The key safety factors were identified as Personal Protective

Equipment (PPE) usage and compliance, the condition of equipment and tools, and worker training. This case study provides a framework to evaluate safety performance and shows its application for evaluating safety of construction site. These case studies indicated that the projects had safety performance indices of 65% and 70%, indicating a "safe" category. This shows that our model can measure safety performance and still identifies areas for improvement in safety performance. Based on the case study, it is evident that certain safety attitudes, including the commitment of management to safety, safety awareness, the presence of inspection and warning systems, are actively practiced on the construction site. In addition, compliance to health and safety insurance was also participated due to stringent enforcement of government regulations. However, the provision of essential components such as comprehensive safety training, safety incentives, and timely equipment maintenance was notably absent. It is because it incurred financial costs for the project. Therefore it is recommended to allocate budget for safety provisions. Besides this, it is recommended to expand safety studies to other construction sectors and beyond Kathmandu Valley.

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