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Development and Application of a Construction Site Risk Index Model Using FMEA for Public Building Projects in Kathmandu Valley, Nepal

by

Anish Karki

A THESIS

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DECLARATION

I hereby declare that the thesis submitted to the Department of Civil Engineering under the title "Development and Application of a Construction Site Risk Index Model Using FMEA for Public Building Projects in Kathmandu Valley, Nepal" in partial fulfilment of the requirement for the Master of Science in Engineering in Construction Management degree. The work was completed under the supervision of Er Subash Kumar Bhattarai and Associate Professor Nagendra Bahadur Amatya. The content of this thesis is entirely my own, with the exception of referenced and acknowledged consulted materials.

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CERTIFICATE OF THESIS APPROVAL

The undersigned certify that we have read and recommended to the Institute of Engineering for acceptance, a thesis entitled "**Development and Application of a Construction Site Risk Index Model Using FMEA for Public Building Projects in Kathmandu Valley, Nepal**" submitted by Anish Karki in partial fulfillment of the requirements for the degree of Master of Science in Construction Management.

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ABSTRACT

Construction site risks remain a significant challenge in public building projects, particularly in developing countries like Nepal, where urbanization pressures, seismic vulnerability, and regulatory complexities intersect. This study focuses on Kathmandu Valley and aims to identify, prioritize, model, and evaluate construction site risk factors using a mixed-method approach. The research is guided by three objectives: (1) to identify and prioritize major risk factors influencing construction site performance using Failure Mode and Effect Analysis (FMEA); (2) to develop a quantitative Construction Site Risk Index (CSRI) model; and (3) to apply the model to evaluate site risk indices through case studies.

A structured questionnaire survey was conducted among 70 construction professionals (32 clients and 38 contractors) working on public building projects in Kathmandu Valley. Reliability analysis using Cronbach's alpha yielded values of 0.88 (clients) and 0.94 (contractors), confirming excellent internal consistency. The correlation coefficient between the Risk Priority Number (RPN) rankings of the clients and contractors is found to be 0.857, indicating a strong positive correlation. The FMEA-based analysis calculated Risk Priority Numbers (RPN) for 48 sub-factors across 8 major risk categories. The top three critical sub-factors were identified as: Late Design Changes (RPN = 37.03), Site-Level Decision-Making and Variation/Change Control (RPN = 36.19), and Scaffolding/Formwork and Temporary Works Stability (RPN = 32.90). A significant awareness-practice gap was also revealed, with 81.4% of respondents demonstrating moderate to high awareness of risk management practices, yet only 18.6% reporting high-level implementation.

Using the normalized RPN values, a CSRI model was developed as a weighted linear combination: CSRI = 0.122(SE) + 0.098(H) + 0.140(SC) + 0.142(TE) + 0.123(MP) + 0.134(DDC) + 0.114(SP) + 0.126(RC). The model classifies site risk into five levels ranging from Very Low (0–0.2) to Very High (0.8–1.0). The CSRI model was then applied to two actual public building projects in Kathmandu Valley: Project A (Sathi Women's Shelter, Bagdol, Lalitpur) yielded a CSRI of 0.36 (Low Risk), while Project B (Integrated Hulak Office Building, Babarmahal, Kathmandu) yielded a CSRI of 0.15 (Very Low Risk). The primary contributors to elevated risk in Project A were Technical and Equipment Factors (0.470) and Safety Management and Procedural Factors (0.510) and in Project B were Site level Project management and Construction Execution

Factors (0.35) and Site Conditions and Environment Factors (0.29), demonstrating the model's ability to identify specific areas requiring targeted intervention.
The study concludes that the CSRI model is a practical, sensitive, and actionable tool for assessing construction site risk in Kathmandu Valley. It bridges the identified awareness-practice gap by providing site managers with a structured yet simple approach to risk assessment. Recommendations include implementing design freeze milestones, empowering site-level decision-making, mandating daily scaffolding inspections, and streamlining permit approval processes.

Keywords: Construction Site Risk Index (CSRI), Failure Mode and Effect Analysis (FMEA), Risk Priority Number (RPN), Risk Assessment, Public Building Projects

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Anish Karki
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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
CBS	Central Bureau of Statistics
CSRI	Construction Site Risk Index
FMEA	Failure Mode and Effects Analysis
RPN	Risk Priority Number
RII	Relative Importance Index
ROI	Risk Occurrence Index
RCI	Risk Consequence Index
RDI	Risk Detectability Index
SPSS	Statistical Package for Social Sciences
ISO	International Organization for Standardization
OHS	Occupational Health and Safety
PPE	Personal Protective Equipment
PMI	Project Management Institute
PSR	Pressure-State-Response
JSA	Job Safety Analysis
NBC	National Building Code
DUDBC	Department of Urban Development and Building Construction

CHAPTER ONE: INTRODUCTION

This chapter describes the study, including its context and aims. This chapter discusses the study's significance, scope, and limits.

1.1 Background

The construction industry is often recognized as one of the most dynamic and complex industries, with a critical role in infrastructure development and economic growth (Flanagan, R., & Norman, G. (1993). Risk Management). It greatly contributes to urban expansion and the delivery of critical public services, raising living standards in developing countries like Nepal (Macroeconomic Update: Nepal (April 2020)). Construction activity in metropolitan areas have increased significantly in recent years, particularly in the Kathmandu Valley, which includes Kathmandu, Bhaktapur, and Lalitpur, due to rising demand for residential, commercial, and public facilities (Office, 2021).

Public infrastructure projects, including educational institutions, healthcare facilities, administrative buildings, and community centers, are crucial to socioeconomic development(Macroeconomic Update: Nepal (April 2020)). These projects are often funded by the government and international development agencies, necessitating efficient resource allocation and accountability. Despite their importance, many public construction projects continue to face considerable obstacles, including project delays, budget overruns, safety concerns, and quality inadequacies(Sekar et al., 2018; Zou et al., n.d.).

Due to their one-of-a-kind characteristics, involvement of multiple stakeholders, and long execution periods, construction projects naturally involve significant uncertainty, making risk management a critical component of project success (Flanagan, R., & Norman, G. (1993). Risk Management.; management & 2014, n.d.). As a result, risk management becomes an essential component in assuring project success. Risks in construction are usually classified into technical, management, financial, and external forms, each influencing project performance in distinct ways (Akintoye et al., 1996; Zou et al., n.d.).

In Nepal, these risks are further intensified by challenges such as limited technical expertise, weak enforcement of regulations, insufficient planning practices, and resource constraints (Pant & Subedi, 2025; Sigdel, 2026). In many cases, construction organizations rely on informal decision-making approaches based on experience rather than structured risk management systems, which increases the likelihood of inefficiencies and unforeseen problems during project execution (engineering & 2018, n.d.).

Risk management is defined as a systematic process of identifying, analyzing, evaluating, and controlling risks to minimize their adverse effects on project objectives (Hutchins, 2018). Among various available techniques, Failure Mode and Effects Analysis (FMEA) has been recognized as an effective tool for risk evaluation in complex systems (Stamatis, 2003). Originally developed for engineering reliability analysis, FMEA has been successfully adapted for construction projects to identify potential failure modes and assess their impacts (Liu et al., n.d.).

The FMEA approach examines risks using three key parameters: occurrence (the probability of the risk event), consequence or severity (the risk's impact), and detectability (the ability to identify the risk before it occurs). These parameters are used to create the risk priority number (RPN), which is stated as $RPN = O \times C \times D$.

Higher RPN values indicate more serious threats that demand prompt attention and mitigation (Stamatis, 2003).

To address these constraints, the creation of a Construction Site Risk Index (CSRI) is required. The CSRI combines several risk indicators into a single quantitative measure, allowing for a systematic assessment and comparison of site dangers. By incorporating FMEA principles, the CSRI provides a disciplined and dependable framework for evaluating construction risks in public building projects.

1.2 Statement of Problem

The construction industry is crucial to Nepal's economy, employing a substantial portion of the population and making a significant contribution to national output (NSO Estimates 4.8% GDP Growth, n.d.). It is recognized as one of the country's largest job-creating sectors (New Business Age, n.d.). However, the industry confronts significant challenges, notably in terms of occupational safety, as an increasing number of accidents and injuries are reported on construction sites (Schulte et al., 2022).

Current risk assessment procedures are often overly broad and fail to account for the unique characteristics and limitations of construction projects in areas such as the Kathmandu Valley, where factors like traditional local labour practices, fluctuating availability of building materials, and specific geotechnical conditions often affect project planning and execution. These local variables are often overlooked, which can decrease the effectiveness of risk identification and management (management & 2014, n.d.). Additionally, with the absence of standard frameworks, risk assessments rely heavily on personal judgment. This causes inconsistencies in evaluation and mitigation methods across construction projects (Zou et al., n.d.). Such variability undermines the overall effectiveness of safety and risk management systems.

As a result, there is a critical need for a localized and data-driven instrument, such as the Construction Site Risk Index (CSRI), that can identify, quantify, and monitor construction site risks. The creation of such an index will enable more informed decision-making, increase safety performance, and improve overall project outcomes in Kathmandu Valley's building sector.

1.3 Research Question

1. What are the major risk factors affecting construction site performance in public building projects within Kathmandu Valley, and how can they be prioritized using Failure Mode and Effect Analysis (FMEA) based on their severity, occurrence, and detectability?
2. How can a quantitative model be developed to measure the construction site risk index by integrating weighted risk factors and their interrelationships for building construction projects specifically in Kathmandu Valley?
3. How does the proposed construction site risk model perform in evaluating and comparing the site risk indices across different construction sites in Kathmandu Valley through a real-world case study?

1.4 Research Objectives

The primary objective of this study is to Develop and Apply of a Construction Site Risk Index Model Using FMEA for Public Building Projects in Kathmandu Valley, Nepal. To achieve primary objective, specific objectives of the study are set as follows:

1. To identify and prioritize major risk factors influencing construction site performance in public building projects within Kathmandu Valley based on Failure Mode and Effect Analysis (FMEA).

2. To develop a model to measure construction site risk index for building construction projects in Kathmandu Valley.
3. To apply the construction site risk model to evaluate site risk index of construction sites in Kathmandu Valley as a case study.

1.5 Significance of the Study

The primary goal of this study is to investigate the factors that influence construction site risk in building projects, develop a structured Construction Site Risk Index (CSRI) model, and assess the risk level of a specific construction site. This study contributes to a better understanding of construction site risks in the Kathmandu Valley and other contexts, while also addressing gaps in Nepal's construction risk management methods. This project creates a localized, data-driven CSRI framework for the Nepalese construction industry. The model is a useful tool for project managers, consultants, and contractors to identify, monitor, and reduce risks on construction projects (Qazi et al., 2021). The study enhances safety and operational efficiency in Nepal's construction sector by focusing on key risk factors and effective management solutions. It also contributes to broader conversations about construction management regulations, compliance standards, and policy development (Author: Department of Urban Development and Building, n.d.; Hutchins, 2018; K. Mishra et al., n.d.).

Furthermore, the study advances the body of knowledge on construction risk management in developing nations by presenting a paradigm that may be adapted for future research and applied beyond Nepal.

1.6 Scope and Limitations

The scope of this study is limited to the Kathmandu Valley, Nepal, with an emphasis on construction site risks in public building projects. The study covers only buildings with more than three stories, excluding high-rise buildings, residential housing, commercial complexes, and infrastructure projects such as roads and bridges. As a result, the findings are applicable only to this specific type of construction project (Author: Department of Urban Development and Building. This study focuses on site-level hazards that construction professionals, such as site engineers and project teams, can directly observe and manage. Broader risks, such as political, economic, and financial uncertainties, are excluded because they fall outside the control of site-level management (Hutchins, 2018). The developed CSRI model is intended to help engineers, contractors, and safety staff assess site conditions and improve safety management practices. It provides a systematic approach to managing day-to-day construction hazards (Qazi et al., 2021; Zissler et al., n.d.).

Despite these limitations, the study offers useful insights into construction site risk assessment, laying the groundwork for future research and the development of risk-indexing methodologies in Nepal's construction sector.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter provides a detailed review of the literature on construction risk assessment, focusing on theories, frameworks, and approaches used globally and in developing countries such as Nepal. The goal of this review is to lay the theoretical groundwork for the creation of a Construction Site Risk Index (CSRI) and to highlight shortcomings in current methods.

Construction risk has been extensively studied because of its significant impact on project performance, particularly cost overruns, delays, and safety concerns (Science & 1993, n.d.; Zou et al., n.d.). Prior research has emphasized that risk is an inherent feature of building projects due to their complexity, dynamic nature, and reliance on multiple interconnected variables.

The review integrates information from books, journal papers, and international standards to better comprehend the core ideas of risk, uncertainty, and risk management. It also investigates the many ways used to identify, assess, and manage risks in building projects.

2.2 Concept of Risk and Uncertainty in Construction

Risk in construction projects is closely tied to uncertainty and its potential impact on project goals. According to (Hutchins, 2018), risk refers to the influence of uncertainty on project objectives, which may lead to either beneficial or adverse outcomes depending on the situation. In construction management, risk is typically expressed as a function of probability and consequence, enabling quantitative evaluation (Qazi et al., 2021; Zissler et al., n.d.). A commonly used conceptual representation is:

Risk = Hazard x Exposure.

where hazard refers to the potential cause of harm and exposure denotes the extent to which the project is affected (research & 2016, n.d.). Uncertainty refers to situations in which several outcomes are possible but their probabilities remain unclear. While all risks contain uncertainty, not all uncertainties are considered dangers unless they affect project objectives (Hueston & Yoe, 2000). This distinction is essential in construction projects, where decisions are often made with insufficient knowledge.

2.3 Definition and Process of Risk Management

Risk management is a systematic method for detecting, analyzing, evaluating, and controlling risks to project outcomes (Hutchins, 2018). It entails following defined methods to address uncertainties caused by financial, technical, environmental, and human issues.

Risks are often stated in terms of likelihood and impact to facilitate prioritization and mitigation planning (Qazi et al., 2021; Zissler et al., n.d.). To be considered substantial, a risk event must have a measurable chance between 0 to 1.

(Davidson & Lambert, n.d.) defines risk management as the procedures of establishing context, detecting risks, analyzing and evaluating risks, treating risks, and continuously monitoring and communicating them. This method ensures that possible dangers are managed proactively throughout the project's lifecycle.

2.4 Risk Assessment Frameworks

To systematically identify, evaluate, and rank risks in building projects, a number of frameworks and techniques have been created. These frameworks offer organized approaches that improve decision-making and project performance in general.

1. Priority Model and Risk Factor

Critical hazards in building projects are frequently identified and ranked using the Risk Factor and Priority Model. This method usually uses structured surveys to gather expert opinions, then quantitative methods like risk matrix analysis and the Relative Importance Index (RII) to assess the importance of various risk factors. The approach helps practitioners identify the most significant risks influencing construction site performance and prioritize mitigation actions by classifying risks into areas including human, organizational, and technological (Dhivya et al., n.d.).

2. Model of Pressure-State-Response (PSR)

A methodical approach to comprehending the connection between activities, site conditions, and mitigation strategies is offered by the Pressure-State-Response (PSR) framework. In this concept, "state" refers to the current state of the construction environment, including safety performance and accident rates, while "pressure" refers to internal or external influences such risky practices or operational expectations. The "response" component stands for the steps done to manage or lessen hazards, including policy interventions, safety training, and the installation of protective measures. This approach is especially helpful for connecting the underlying causes of risks to their effects and the appropriate control measures.

3. The Framework for ISO 31000 Risk Management

A widely accepted set of guidelines for risk management in several industries, including construction, is provided by the ISO 31000 standard. It encourages an organized and methodical approach and highlights the incorporation of risk management into organizational procedures. Important phases including risk identification, risk analysis, risk appraisal, and risk treatment are included in the framework. It also emphasizes key ideas like diversity, flexibility, and ongoing development. ISO 31000 can be used in construction projects to address site-specific issues as well as organizational-level hazards, guaranteeing a thorough risk management procedure.

4. Occupational Health and Safety Framework ISO 45001

The improvement of occupational health and safety (OHS) in workplaces is the specific focus of ISO 45001. It offers an organized method for detecting risks, lowering workplace dangers, and improving safety performance. Leadership dedication, employee involvement, methodical risk and opportunity management, operational control, and emergency preparedness planning are important components of this framework. Adoption of ISO 45001 in the construction industry guarantees regulatory compliance and fosters the growth of a robust safety culture.

5. Multi-Framework Method

To provide a more thorough evaluation of building site risks, a multi-framework approach combines many theoretical and practical models. This method incorporates international standards like ISO 31000 and ISO 45001, conceptual frameworks like the PSR model, and academic models like the Risk Factor and Priority Model. This approach enables a comprehensive assessment of risks from several angles, including human, technical, environmental, and regulatory dimensions, by utilizing the advantages of each framework.

6. Mixed-Methods Approach

To provide a comprehensive understanding of construction risks, the mixed-methods approach integrates both quantitative and qualitative research techniques. To quantify and rank risks objectively, quantitative techniques like surveys and statistical tools like the Relative Importance Index (RII) and risk matrix analysis are employed. Conversely, qualitative approaches—such as field observations, interviews, and case studies—assist in investigating perceptions, site practices, and underlying reasons. Data triangulation is made possible by this integration, which enhances the accuracy and comprehensiveness of risk assessment in building studies.

2.5 Failure Mode and Effects (FMEA)

According to possible failure modes, FMEA is an organized method for identifying and ranking risks (Stamatis, 2003). Three criteria are used to assess risks: Occurrence (O), Consequences (C), and Detectability (D)

The following formula is used to determine the Risk Priority Number (RPN): RPN = O × C × D.

$RPN = ROI \times RCI \times RDI$

$ROI = (\sum W_o) / (A \times N)$

$RCI = (\sum Wc) / (A \times N)$

$RDI = (\sum Wd) / (A \times N)$

More serious dangers that need to be addressed right away are indicated by higher RPN values (Liu et al., n.d.). Because FMEA can provide systematic and quantitative risk evaluation, it is frequently employed in the construction industry.

2.6 Key Risk Categories

Based on the comprehensive review of existing literature, the following factors have been identified as key contributors to site risk during building construction projects.

Table 1: Risk factors impacting construction sites during Building Construction.

Risk Type	**Key Factors**	**Authors**
Environmental Risk	Weather	(countries & 2015; Zou et al., n.d.)
	Earthquakes	
	Site accessibility	
	Floods	
Technical Risk	Design errors	(Zou et al., n.d.)

	Constructability issues	
	Equipment failure	
Geotechnical Risk	Soil instability	(Zou et al., n.d.)
	Foundation failure	
Social Risk	Labor strikes	(countries & 2015)
	Public opposition	
Financial Risk	Inflation	(Doloi et al., n.d.)
	Funding delays	
	Cost escalation	
Operational Risk	Low productivity	(Doloi et al., n.d.)
	Miscommunication	
	Delays	
Technological Risk	Software failure	(management & 2014, n.d.)
	Lack of skilled operators	
Political Risk	Policy changes	(management & 2014, n.d.)
	Strikes	
	Government changes	
Communication Risk	Delayed communication	(Qazi et al., 2021)
	Misinterpretation	
Management Risk	Poor planning	(Flanagan, R., & Norman, G. (1993). Risk Management)
	Lack of experience	
	Coordination issues	
Market Risk	Material price fluctuation	(Sekar et al., 2018)
	Labor cost variation	
Legal Risk	Contract disputes	(Akintoye et al., 1996)
	Permit delays	
	Legal compliance	

Table 2: Construction Risks in Developing Countries (Nepal Context)

Risk Type	**Key Factors**	**Authors**
Technical Risks	Poor design detailing	(Shen et al., 2001; Zou et al., n.d.)
	Lack of standardization,	

	Inadequate site investigation	
Resource Risks	Skilled labor shortage	(Dhivya et al., n.d.)
	Dependency on imports	
	Equipment unavailability	
Environmental Risks	Earthquakes	(countries & 2015; Shen et al., 2001)
	Monsoon rainfall	
	Landslides	
	Difficult terrain	
Regulatory Risks	Weak enforcement of building codes Bureaucratic delays in approvals	(countries & 2015, 2015; Flanagan, R., & Norman, G. (1993). Risk Management)
Site Condition Risks	Congested urban sites	(Shen et al., 2001; Zou et al., n.d.)
	Limited access roads	
	Traffic interference	
Managerial Risks	Poor scheduling	(Zou et al., n.d.)
	Weak site supervision	
	Lack of coordination among stakeholders	
Contractual Risks	Contract clauses	(Zou et al., n.d.)
	Dispute resolution delays	
External Risks	Natural disasters	(management & 2014, n.d.; Zou et al., n.d.)
	Economic instability	
	Pandemics	
Political Risks	Policy changes	(management & 2014, n.d.)
	Strikes (bandhs)	
	Administrative interference	
Financial Risks	Budget constraints	(Doloi et al., n.d.; Sekar et al., 2018)
	Delayed payments	
	Inflation and price fluctuation	

Safety Risks	Low PPE usage Poor safety culture Lack of training	(International Labour Organization (2022) – Safety, n.d.; Shrestha et al., n.d.; Zeng et al., n.d.)
Communication Risks	Language barriers Informal communication systems Poor documentation	(Dainty et al., 2007)
Geotechnical Risks	Unstable soil Groundwater issues Slope instability	(countries & 2015, 2015; Sharma et al., n.d.)
Supply Chain Risks	Delays in material delivery Dependency on cross-border supply	(Doloi et al., n.d.)
Human Factors	Untrained workforce Fatigue Unsafe practices	(Sharma et al., n.d.; Zeng et al., n.d.)

2.7 Construction Risk Assessment in Nepal

In Nepal, job safety analysis (JSA), safety checklists, and informal assessments are commonly used for risk assessment. These approaches rely heavily on human judgment and are often inconsistent.

Despite the existence of legal frameworks such as the Building Act and the Labour Act, their implementation remains inadequate. Research emphasizes the lack of quantitative, structured risk assessment approaches adapted to local building characteristics (Shrestha et al., n.d.).

2.8 Development of Risk Index Models

Risk indices, which are quantitative instruments, combine several risk characteristics into a single number. Weighted scoring and statistical methods such as regression analysis are frequently used in these models (Doloi et al., n.d.). Risk indices aid decision-making in the construction industry by highlighting risks and optimizing resource allocation. However, accurate calibration and validation using local data are necessary for their effectiveness.

2.9 Research Gap

Although several risk assessment methods are available, their lack of contextual adaptation limits their applicability in Nepal. For public building projects in the Kathmandu Valley, there is currently no standard Construction Site Risk Index.

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter explains the research design and methodological framework adopted for the development and evaluation of the Construction Site Risk Index (CSRI) for public building projects in Kathmandu Valley. It presents the overall research framework, techniques of data collection, analytical tools, and validation procedures applied throughout the study.

3.1 Research Methodology

The research was carried out through a systematic sequence of steps.

- Initially, the study began with the selection of a research topic and formulation of research questions. This was followed by identifying the research problem, defining clear objectives, and establishing an appropriate research strategy.
- The next stage involved an extensive review of existing literature to identify key risk factors influencing construction site performance in building projects. The findings from the literature were further strengthened through expert consultations and interviews, ensuring their relevance to the local construction context. A panel of five domain experts was consulted: Expert 1 (Urban and Building Officer, 20 years of experience) provided insights on regulatory compliance and land management; Expert 2 (Project Manager, 18+ years in private sector) contributed practical perspectives on site-level decision-making and technical risks; Expert 3 (DUDBC Officer, 14+ years) validated building code compliance and seismic vulnerability factors; and Expert 4 (DUDBC Officer, 12+ years) contributed to understanding of permit processes and safety regulation enforcement; Expert 5 (Academician, 20+ years in risk management) validated the FMEA methodology and factor categorization. Based on their collective feedback, one additional major factor (Regulatory and Compliance Factors) was added, and several sub-factors were merged or newly included. As a result, a total of 8 factors and 48 sub-factors were finalized.
- Subsequently, a structured questionnaire was developed for data collection. The design of the questionnaire was guided by previous studies, including those by (Abdalfatah et al., 2023; A. Mishra et al., n.d.; Sharma et al., n.d.), with necessary modifications to reflect the conditions of the Nepalese construction

industry. Expert input was incorporated during its development, and a pilot survey was conducted to test clarity, reliability, and to minimize potential bias.

- Data collection was then carried out using a structured questionnaire survey targeting key stakeholders such as contractors, engineers, and construction workers directly involved in building projects. The collected data were coded and analyzed using Statistical Package for Social Sciences (SPSS) and Microsoft Excel, which were used for statistical analysis and data visualization.
- Based on the results of the analysis, the Construction Site Risk Index (CSRI) model was developed by integrating the principles of Failure Mode and Effects Analysis (FMEA), as discussed in the literature. The developed model was then applied to a case study of a public building project in Kathmandu Valley to evaluate its practical applicability.
- Finally, the results were interpreted and discussed in detail, leading to conclusions and recommendations aimed at improving construction site risk management practices.

A mixed-method approach was adopted in this study, combining both quantitative and qualitative techniques.

Quantitative data were collected through Likert-scale-based questionnaires administered to contractors, engineers, and safety personnel

Qualitative insights were obtained through expert interviews.

The overall process followed a sequential approach, including risk identification, data collection, statistical analysis, index development, and model validation.

3.2 Research Design

The research approach used to accomplish the study's goals is presented in this chapter. The research methodology, research design, study area, population and sample size determination, statistical tools and methodologies, data collection methods, data analysis procedures, and model creation are among the important topics covered. All things considered, this chapter offers a methodical framework for carrying out the research.

In order to achieve the research goals, a thorough grasp of the study context and prior research on construction site risk was first obtained by a systematic examination of the literature. The review emphasized the necessity of evaluating risks in building construction projects, especially in the context of the Kathmandu Valley, and assisted in identifying research gaps and developing pertinent research questions. To guarantee a thorough and comprehensive coverage of current information, a variety of sources, including journal articles, technical reports, and thesis studies, were reviewed in order to support the creation of the Construction Site Risk Index (CSRI).

The research design is the conceptual framework used to conduct the study. In order to achieve the aforementioned objectives, it provides a broad outline of how this study will be carried out.

This basic research methodology is to be carried out for obtaining research objectives as the flow chart is shown in figure 1 below. Similarly, research framework is presented in figure 2.

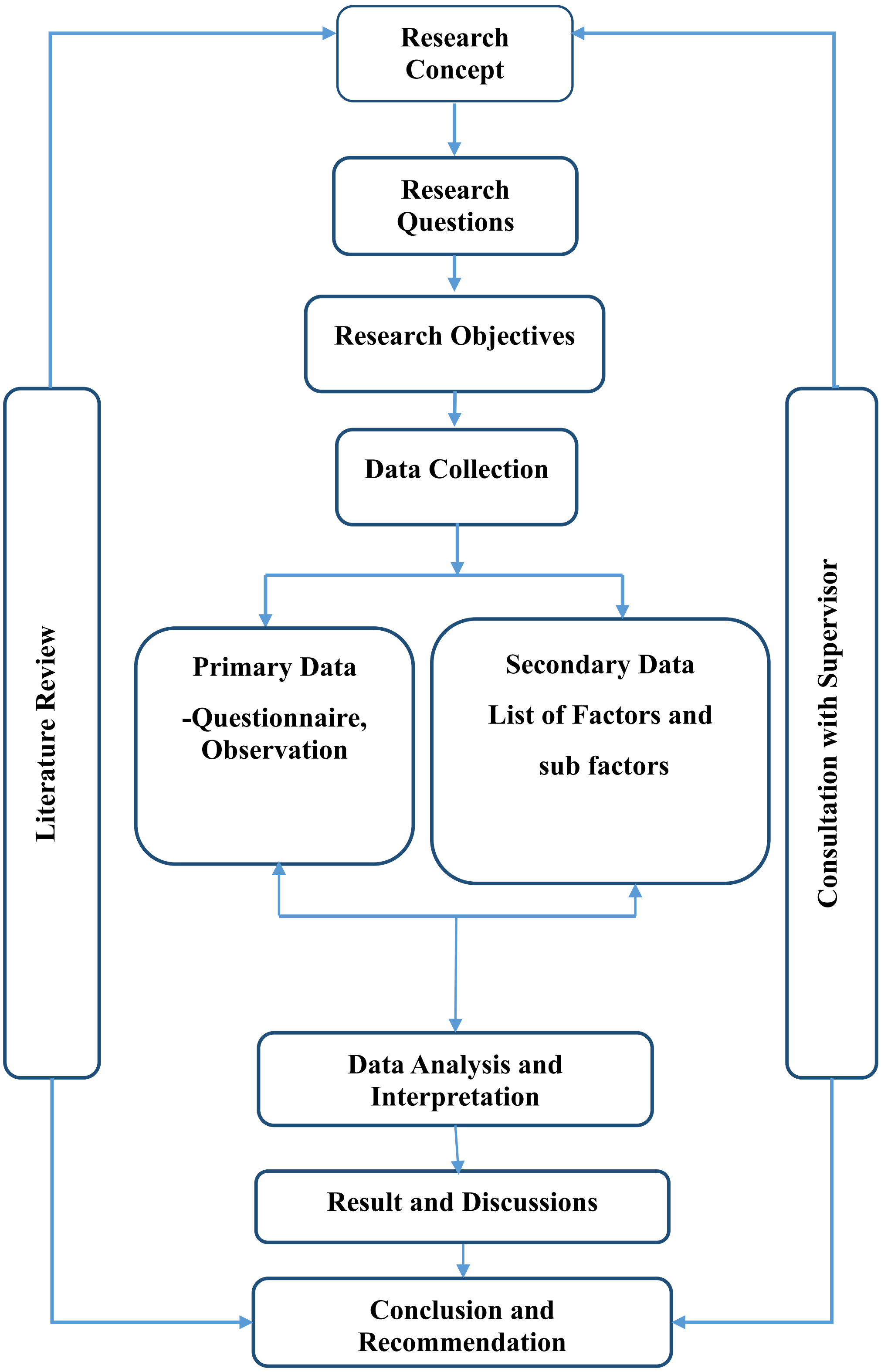

Figure 2: Research design flow chart

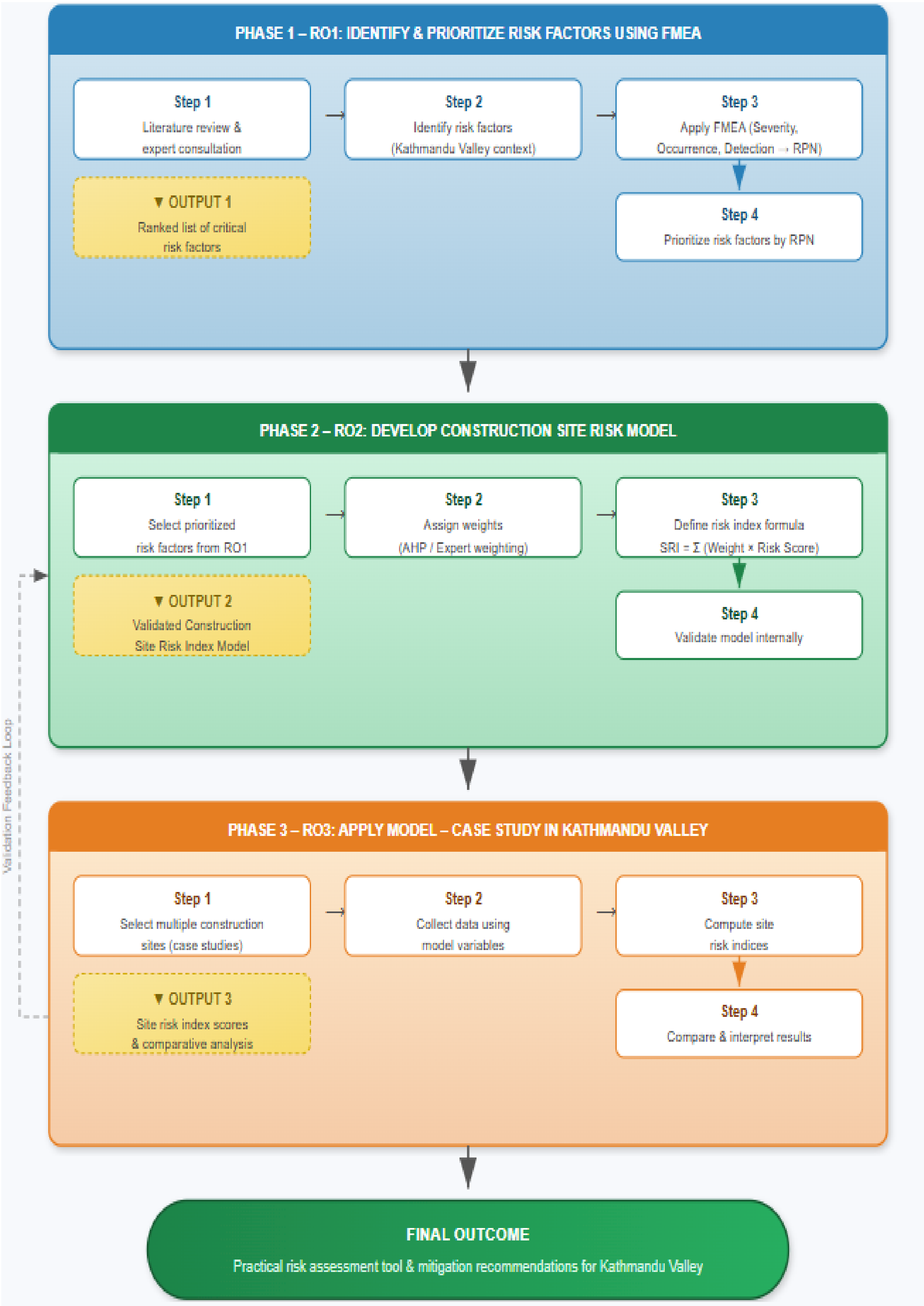

Figure 3: Research Framework

3.3 Study Area

The study is confined to the public building construction sector within Kathmandu Valley, including Kathmandu, Lalitpur, and Bhaktapur districts. The selection was based on the following criteria:

- **Nature of Project:** Public building construction
- **Geographical Coverage:** Kathmandu Valley (Kathmandu, Lalitpur, Bhaktapur)

3.4 Study Population, Sample Selection and Sample size

The target population consisted of all key stakeholders actively involved in these construction sites, including project managers, contractors, engineers, supervisors, safety officers involved in building design and supervision within Kathmandu Valley. Also, for the case study, two projects from different locations (Kathmandu and Lalitpur) were **purposively selected**.

Using Cochran's formula, the sample size was determined as follows:

$n_0 = z^2pq/e^2$-- (i)

where,

n_0 is the sample size,

z is the z-score corresponding to the desired confidence level,

p is the estimated proportion of the population,

$q = 1 - p$,

e is the margin of error.

Assuming the population size is infinite,

From equation (i),

$n_0 = z^2pq/e^2$

Calculation:

Here for 90% confidence level;

z= 1.64; e=0.1 and p=0.5, q=0.5

$$n_0 = \frac{1.64 * 1.64 * 0.5 * 0.5}{0.1 * 0.1}$$

= 67.24

i.e. 68 numbers

Therefore, the sample size was taken as 68 as per calculation.

A non-probability, purposive sampling technique was used to identify the respondents. Questionnaire were sent to 80+ respondents, out of which 70 respondents participated in the survey.

3.5 Methods of data Collection

3.5.1 Primary Data Collection

Primary data were collected to obtain firsthand information directly from the field. In this study, original data were gathered through structured questionnaire surveys conducted both online and through on-site interactions, including interviews.

The data collection process was carried out in **two phases**:

Table 3: Phase of Primary Data Collection

Phase	Focus	Activity
Phase 1	Identify & develop CSRI model	Questionnaire survey for FMEA (Severity, Occurrence, Detectability ratings)
Phase 2	Apply CSRI model in case studies	Field survey, interviews, and CSRI calculation for selected construction sites

3.5.2 Secondary Data Collection

Secondary data were obtained from existing sources such as research articles, journals, reports, books, websites, and other relevant publications. These sources were primarily used to identify potential construction site risk factors. The identified factors were then validated in the Nepalese context through expert consultation and a pilot survey.

3.6 Data Analysis

Data analysis in this study refers to the statistical and analytical processing of data collected from both primary and secondary sources. Tools such as **Microsoft Excel** and **Statistical Package for the Social Sciences (SPSS)** were utilized to organize, summarize, and interpret the data.

The data analysis is structured according to the three research objectives:

Table 4: Data Analysis Method

Research Objective	Data Analysis Method
RO1: Identify & prioritize risk factors using FMEA	RII (ROI, RCI, RDI) + RPN Calculation + Ranking
RO2: Develop CSRI model	Weight Calculation + CSRI Formula Development
RO3: Apply CSRI model in case studies	CSRI Computation + Comparative Analysis

3.6.1 Descriptive Statistics

Descriptive statistics were used to organize and present data in a meaningful way, enabling clear interpretation through tables, graphs, and charts. In this study, descriptive statistical methods were applied to:

- Analyze demographic characteristics of respondents (age, experience, role, etc.)
- Summarize collected data effectively

3.6.3 Data Analysis for RO1: Risk Factor Prioritization Using FMEA

For **RO1**, the following analytical steps were conducted:

Step 1: Relative Importance Index (RII) Calculation

After performing the questionnaire survey, responses were analyzed using the **Relative Importance Index (RII)** method, which is given by:

$RII = \Sigma W / (A \times N)$

Where:

- ΣW = Sum of responses (i.e., sum of crisp ratings given by respondents)
- A = Maximum value of crisp rating (5)
- N = Number of respondents

As per the RII concept, **Risk Occurrence Index (ROI)**, **Risk Consequence Index (RCI)**, and **Risk Detectability Index (RDI)** for each risk factor were calculated using the following formulas (Sharma et al., n.d.):

$ROI = \Sigma WO / (A \times N)$

$RCI = \Sigma WC / (A \times N)$

$RDI = \Sigma WD / (A \times N)$

Step 2: Risk Priority Number (RPN) Calculation

The Risk Priority Number (RPN) was calculated using the three indices:

$RPN = ROI \times RCI \times RDI \times 100$

Step 3: Ranking of Risk Factors

Risk factors were ranked in **descending order** of their RPN values. A higher RPN indicates a more significant risk.

Output of RO1 Data Analysis: Ranked list of 48 risk factors with their RPN values.

3.6.4 Data Analysis for RO2: CSRI Model Development

For **RO2**, the RPN outputs from RO1 were further analyzed to develop the Construction Site Risk Index (CSRI) model.

Step 1: Weight Calculation for Each Risk Factor

The weight of each of the 8 risk factors was calculated based on its RPN relative to the sum of all RPNs:

$WSE = RPN\_SE / (RPN\_SE + RPN\_H + RPN\_SC + RPN\_TE + RPN\_MP + RPN\_DDC + RPN\_SP + RPN\_RC)$

Similarly, for:

- WH (Human Factors)
- WSC (Site Management & Construction Execution)
- WTE (Technical & Equipment)
- WMP (Material & Procurement)
- WDDC (Design, Documentation & Coordination)
- WSP (Safety Management & Procedural)
- WRC (Regulatory & Compliance)

Step 2: CSRI Formula Development

The Construction Site Risk Index was formulated as:

CSRI = (WSE × SE) + (WH × H) + (WSC × SC) + (WTE × TE) + (WMP × MP) + (WDDC × DDC) + (WSP × SP) + (WRC × RC)

Where:

- **SE, H, SC, TE, MP, DDC, SP, RC** = Compensative coefficients for their respective factors (site-specific risk scores ranging from 0 to 1)

Step 3: Risk Level Classification

Table 5: Risk Level of CSRI value

CSRI Value	Risk Level
0.00 – 0.20	Very Low Risk
0.21 – 0.40	Low Risk
0.41 – 0.60	Moderate Risk
0.61 – 0.80	High Risk
0.81 – 1.00	Very High Risk

Output of RO2 Data Analysis: Validated CSRI mathematical model with factor weights and risk classification thresholds.

3.6.5 Data Analysis for RO3: Case Study Application

For **RO3**, the developed CSRI model was applied to selected construction sites in Kathmandu Valley.

Step 1: Site-Specific Data Collection

For each case study site, data were collected on the 8 risk factors using:

- Site observations
- Interviews with site engineers and managers
- Document review

Each factor was assigned a **site-specific risk score (0 to 1)** based on actual site conditions.

Step 2: CSRI Computation for Each Site

Using the CSRI formula from RO2:

$$CSRI\_Site = \Sigma\ (Weight\_Factor \times Site\_Risk\_Score\_Factor)$$

Step 3: Comparative Analysis

CSRI values across different construction sites were compared using:

Table 6: Analysis Method & its purpose

Analysis Method	**Purpose**
Descriptive comparison	Rank sites by risk level
Bar charts / radar charts	Visual comparison of factor-wise risk profiles
Risk level classification	Categorize each site (Very Low to Very High)

Output of RO3 Data Analysis: Numerical CSRI values for each case study site and comparative analysis of site risk levels.

Summary of Data Analysis Across All ROs

Table 7: Data Analysis of R01, R02 & R03

Research Objective	Data Input	Analysis Method	Output
RO1	Raw survey ratings (1-5) for S, O, D	RII (ROI, RCI, RDI) → RPN → Ranking	Ranked risk factors with RPN values
RO2	RPN values of 8 risk factors	Weight calculation → CSRI formula → Risk thresholds	CSRI mathematical model
RO3	Site-specific risk scores (0-1) for 8 factors	CSRI computation → Comparative analysis	Site risk indices & comparison

3.7 Reliability Statistics

The reliability, or internal consistency, of the survey data was evaluated using **Cronbach's alpha (α)**. This statistical measure assesses the degree to which items within a dataset are consistent in measuring the same concept.

Formula:

Cronbach's $\alpha = [k/(k-1)] \times [1 - (\Sigma\sigma^2 y / \sigma^2 x)]$

Interpretation of Cronbach's Alpha:

Table 8: Cronbach's alpha Value

Cronbach's α	Internal Consistency
0.9 – 1.0	Excellent
0.8 – 0.89	Very Good
0.7 – 0.79	Good
0.6 – 0.69	Questionable

0.5 – 0.59	Poor

Reliability Test Results:

Table 9: Reliability Statistics Value

S.N.	Perspective	No. of Questions (K)	No. of Respondents (N)	Cronbach's Alpha
1	Client	48	32	0.88 (Very Good)
2	Contractor	48	38	0.94 (Excellent)

The Cronbach's alpha values of **0.88** and **0.94** suggest the dataset has very good to excellent reliability.

3.8 Correlation Analysis

Spearman's rank correlation coefficient (ρ) is a non-parametric statistical measure used to assess the strength and direction of the monotonic relationship between two variables. The value of the coefficient ranges from −1 to +1, where values closer to +1 indicate a strong positive correlation, values closer to −1 indicate a strong negative correlation, and values around 0 indicate little or no correlation.

The interpretation of Spearman's correlation coefficient is as follows: values between 0.00–0.29 indicate a weak correlation, 0.30–0.49 indicate a moderate correlation, and 0.50–1.00 indicate a strong correlation.

Correlation Test Results:

The Spearman's rank correlation coefficient (ρ) between the RPN rankings of clients and contractors was found to be **0.857**, indicating a strong positive correlation.

3.9 Research Matrix

Research matrix of the study is presented in table below.

Table 10: Research Matrix

Research Objective	**Data Required**	**Data Source**	**Analytical Tools / Methods**	**Expected Outcome**
To identify and prioritize site risk factors using FMEA	Severity, Occurrence, Detectability ratings (1-5 scale)	Engineers, Contractors, Supervisors, Safety Officers, Consultants, Project Managers (Kathmandu Valley)	Questionnaire survey, RII (ROI, RCI, RDI), RPN calculation, Ranking	Ranked list of risk factors based on Risk Priority Number (RPN)
To develop the Construction Site Risk Index (CSRI) model	Prioritized risk factors and corresponding RPN values from RO1	Processed survey data (RO1 outputs)	Weight calculation ($W = RPN/\Sigma RPN$), CSRI formula development, Risk level classification	Validated CSRI mathematical model for quantifying site risk
To apply the CSRI model in real projects (case study)	Project-specific risk data (site scores 0-1 for 8 factors)	Selected public building construction sites in Kathmandu Valley	Field survey, site observations, interviews, CSRI computation, comparative analysis	Numerical CSRI values for each site and comparison of site risk levels

CHAPTER FOUR: RESULTS AND DISCUSSIONS

This chapter presents the analysis and interpretation of the data collected, based on the methodology outlined in Chapter Three. The dataset was processed using Microsoft Excel and SPSS to perform statistical analysis. The results are organized according to the three research objectives:

- **Section 4.1** – Results for RO1: Identification and Prioritization of Risk Factors Using FMEA
- **Section 4.2** – Results for RO2: Development of Construction Site Risk Index (CSRI) Model
- **Section 4.3** – Results for RO3: Application of CSRI Model in Case Study

The results are illustrated through tables and bar charts for clear and effective presentation, followed by detailed discussions.

4.1 Identification and Prioritization of Risk Factors Using FMEA

This section addresses the first research objective: To identify and prioritize major risk factors influencing construction site performance in public building projects within Kathmandu Valley based on Failure Mode and Effect Analysis (FMEA).

4.1.1 Finalized Risk Factors from Expert Consultation

As a result of the risk identification process described in Chapter 3, which involved literature review followed by expert consultation to contextualize factors for Kathmandu Valley, a total of 8 major risk factors and 48 sub-factors were finalized. These are presented in Table 11.

Table 11: Finalized Risk Factors and Sub-Factors for Kathmandu Valley

S.N.	Risk Factor	Sub-Factors
1	**Site Conditions and Environmental Factors**	a) Geotechnical / ground and soil conditions b) Seismic vulnerability during construction c) Site layout & congestion (space constraints)

		d) Access, traffic & logistics e) Weather & climate impacts f) Surrounding hazards & public interface g) Force majeure events h) Land management issues
2	**Human Factors**	a) Worker skill level b) Labour turnover & reliance on temporary workforce c) Language / communication barriers and supervision quality d) Fatigue, working hours, and shift patterns e) Unsafe acts f) Worker safety awareness and individual reporting behavior
3	**Site Level Project Management and Construction Execution Factors**	a) Contractor / site management competence b) Subcontractor coordination c) Planning and scheduling effectiveness d) Site level decision-making and variation/change control e) Pandemic and health emergency management
4	**Technical and Equipment Factors**	a) Equipment condition, maintenance & inspection b) Heavy machinery operations & operator competence c) Scaffolding/formwork and temporary works stability d) Lifting operations & crane interface

		hazards e) Struck-by-Object Hazards f) Fire and Explosion hazards g) Electrical safety & temporary power arrangements
5	**Material and Procurement Factors**	a) Material quality control & compliance with specifications b) Material handling & storage practices c) Supply chain reliability d) Theft / vandalism / security of stored materials e) Material damage and wastages
6	**Design, Documentation and Coordination Factors**	a) Incomplete or unclear drawings / specification b) Design errors and omissions c) Late design changes d) Inadequate design provision for safe construction e) Constructability issue f) Interdisciplinary coordination
7	**Safety Management and Procedural Factors**	a) Safety leadership and commitment b) Frequency & quality of safety inspections / audits c) Availability & correct use of PPE d) Emergency preparedness and evacuation plans e) Formal incident reporting systems and procedures f) Safety training programs and toolbox talks

8	**Regulatory and Compliance Factors**	a) Permit and approval delays b) Compliance with building codes c) Enforcement of safety regulations d) Record-keeping, authority inspections & documentation e) Environmental regulations

Discussion: The expert consultation process successfully localized the initial 7 factors and 35 sub-factors identified from literature to 8 factors and 48 sub-factors specific to the Kathmandu Valley context. New additions included Land management issues under Site Conditions (reflecting land ownership disputes common in Kathmandu Valley), Pandemic and health emergency management under Project Management (reflecting COVID-19 impacts), and Struck-by-Object Hazards under Technical Factors (a leading cause of construction fatalities). This localized framework formed the basis for the subsequent questionnaire survey and FMEA analysis.

4.1.2 Response Rate

A total of 80 questionnaires were distributed to construction professionals working in public building projects within Kathmandu Valley. Out of these, 70 valid responses were received, yielding a response rate of 87.5%, which is considered excellent for construction industry surveys.

Table 12: Respondent Data

Category	**Count**
Total questionnaires sent	80
Total responses received	70
Site Engineer	42
Project Manager	18
Consultant Engineer	10
Client	32

Contractor	38
Response Rate	**87.5%**

Discussion: The high response rate (87.5%) indicates strong interest and engagement from construction professionals in Kathmandu Valley regarding site risk management. The distribution of respondents (42 Site Engineers, 18 Project Managers, 10 Consultant Engineers) ensures diverse perspectives. The representation of both clients (32) and contractors (38) allows for comparative analysis between these two key stakeholder groups.

4.1.3 Demographic Profile of Respondents

A total of 70 valid responses were analyzed. The demographic characteristics of respondents, including gender, job title, professional experience, stakeholder perspective, and number of projects executed, are summarized in Table 13.

Table 13: Demographic Profile of Respondents (n=70)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	60	85.7
	Female	10	14.3
Job Title	Site Engineer	42	60.0
	Project Manager	18	25.7
	Consultant Engineer	10	14.3
Professional Experience	0-2 years	6	8.6
	2-5 years	34	48.6
	5-10 years	22	31.4
	10+ years	8	11.4
Stakeholder Perspective	Client	32	45.7

	Contractor	38	54.3
Number of Projects Executed	0-10	19	27.1
	10-20	27	38.6
	20-30	17	24.3
	30+	7	10.0

Discussion: The demographic profile indicates that the majority of respondents were male (85.7%), reflecting the current gender distribution in the Nepalese construction industry, while female representation (14.3%) suggests increasing participation of women in construction management roles. Site engineers constituted the largest occupational group (60.0%), which is appropriate as they are directly involved in day-to-day site operations and risk management, followed by project managers (25.7%) and consultant engineers (14.3%). In terms of experience, 80.0% of respondents had between 2 and 10 years of professional experience, representing a balanced mix of early-career and mid-career professionals, while those with over 10 years of experience (11.4%) provided valuable senior perspectives. The near-equal distribution between clients (45.7%) and contractors (54.3%) enables meaningful comparison of risk perceptions between these two key stakeholder groups. Regarding project execution history, the majority of respondents (62.9%) had executed between 10 and 30 projects, indicating substantial practical experience, while those with over 30 projects (10.0%) represent highly experienced professionals whose insights carry significant weight in the analysis.

4.1.4 Current Site Risk Management Practices

The current state of site risk management practices among construction professionals in Kathmandu Valley was assessed across four dimensions: awareness, practice implementation, formal technique application, and risk analysis technique usage. Table 14 presents a consolidated summary of these findings.

Table 14: Current Site Risk Management Practices (n=70)

Practice Area	Level	Frequency (n)	Percentage (%)
Awareness of Risk Management	Slightly Aware	13	18.6
	Moderately Aware	30	42.9
	Highly Aware	24	34.3
	Most Aware	3	4.3
Risk Management Practice Followed	Least Practice	5	7.1
	Slightly Practice	21	30.0
	Moderately Practice	31	44.3
	Highly Practice	11	15.7
	Most Practice	2	2.9
Formal Techniques Applied	Least	6	8.6
	Slightly	24	34.3
	Moderately	31	44.3
	Highly	9	12.9
Risk Analysis Techniques Used	Least used	6	8.6
	Slightly used	32	45.7
	Moderately used	26	37.1
	Highly used	6	8.6

Discussion: The results reveal a concerning awareness-practice gap in site risk management among construction professionals in Kathmandu Valley. While 81.4% of respondents reported being moderately to highly aware of site risk management practices, only 18.6% indicated that such practices are followed to a high or most practice level. Similarly, although 81.5% demonstrated moderate to high awareness, only 12.9% reported applying formal risk management techniques at a high level, and merely 8.6% reported high usage of structured risk analysis techniques. This pattern indicates that while construction professionals possess theoretical knowledge of risk management, this awareness does not translate into systematic implementation on site. The moderate levels (44.3%) dominating all four dimensions suggest that risk management is practiced informally rather than through structured frameworks. These findings justify the development of the CSRI model as a practical, user-friendly tool that can bridge this awareness-practice gap by providing site managers with a structured yet simple approach to risk assessment that does not require specialized software or extensive training.

4.1.5 Methods for Identifying, Analyzing, and Responding to Site Risks

Respondents were asked about the specific methods they use for risk identification, analysis, and response. Tables 15,16&17 summarize these findings.

Table 15: Methods for Identifying Potential Site Risks (n=70)

Method	Frequency (n)	Percentage (%)
Brainstorming	6	8.6
Contract document	4	5.7
Expert Opinion	19	27.1
Monitoring and Evaluation Report of similar past projects	35	50.0
Risk Register	6	8.6

Discussion: The most common method for risk identification is using "Monitoring and Evaluation Reports of similar past projects" (50.0%), followed by "Expert Opinion" (27.1%). This indicates that risk identification in Kathmandu Valley relies heavily on experiential learning and historical data rather than formal risk registers or structured techniques. The low usage of risk registers (8.6%) suggests a lack of formal documentation practices.

Table 16: Methods for Analyzing Site Risks (n=70)

Method	Frequency (n)	Percentage (%)
Comparative analysis	10	14.3
Descriptive analysis	8	11.4
Direct Judgment	25	35.7
Probability analysis	11	15.7
Ranking Options	16	22.9

Discussion: "Direct Judgment" (35.7%) is the most common risk analysis method, highlighting the subjective nature of current practices. This reliance on personal judgment without structured tools increases the risk of bias and inconsistency. The moderate usage of ranking options (22.9%) and probability analysis (15.7%) suggests some awareness of structured techniques, but their application remains limited.

Table 17: Methods for Responding to Site Risks (n=70)

Response Method	Frequency (n)	Percentage (%)
Avoiding the risk	5	7.1
Mitigating the risk	16	22.9
Monitoring the risk and preparing Contingency Plan	49	70.0

Discussion: An encouraging 70.0% of respondents use proactive risk response strategies (monitoring and contingency planning), while only 7.1% rely on risk avoidance. This indicates a mature approach to risk management among construction professionals in Kathmandu Valley, recognizing that most construction risks cannot be avoided but must be managed through active monitoring and preparedness.

4.1.6 Perceived Importance of Risk Factors

Respondents were asked to identify the factors they perceived as contributing most significantly to site risks. Table 18 presents the results.

Table 18: Most Important Factors During Building Construction Activities (n=70)

Risk Factor	Frequency (n)	Percentage (%)
Design, Documentation and Coordination Factors	32	45.7
Site level Project management and Construction Execution Factors	29	41.4
Site Conditions and Environment Factors	22	31.4
Technical and Equipment Factors	15	21.4
Safety Management and Procedural Factors	17	24.3
Human Factors	11	15.7
Regulatory and Compliance Factors	10	14.3
Material and Procurement Factors	7	10.0

Note: Multiple responses were permitted; percentages do not sum to 100.

Discussion: Respondents identified Design, Documentation and Coordination Factors (45.7%) as the most critical, followed by Site-level Project Management and Construction Execution Factors (41.4%). This finding aligns with the high RPN values for "Late design changes" and "Site level decision-making" in the subsequent quantitative analysis. Material and Procurement Factors received the lowest frequency (10.0%), suggesting that supply chain issues are perceived as less critical than design and management factors in the Kathmandu Valley context. The high ranking of design and management factors indicates that stakeholders recognize the importance of upstream decisions (design quality, change management) and on-site execution decisions as primary drivers of construction site risk.

4.1.7 Risk Priority Number (RPN) Calculation and Ranking of Sub-Factors

The RPN for each sub-factor was calculated using the formula:

RPN = ROI × RCI × RDI × 100

Where:

- **ROI** (Risk Occurrence Index) = ΣWO / (A × N)
- **RCI** (Risk Consequence Index) = ΣWC / (A × N)
- **RDI** (Risk Detectability Index) = ΣWD / (A × N)

4.1.6.1 Top 10 Sub-Factors from Client Perspective

Table 19: Top 10 Sub-Factors – Client Perspective

Rank	**Sub-Factor**
1	Site level decision-making and variation/change control
2	Heavy machinery operations & operator competence
3	Electrical safety & temporary power arrangements
4	Pandemic and health emergency management
5	Land management issues
6	Material quality control & compliance with specifications
7	Worker safety awareness and individual reporting behavior
8	Equipment condition, maintenance & inspection
9	Lifting operations & crane interface hazards
10	Inadequate design provision for safe construction

Discussion: From the client perspective, site-level decision-making ranks highest, reflecting client concerns about unauthorized changes and poor on-site decisions that impact project cost and timeline. The presence of multiple technical factors (heavy machinery, electrical safety, lifting operations) indicates clients prioritize operational safety risks.

Top 10 Sub-Factors from Contractor Perspective

Table 20: Top 10 Sub-Factors – Contractor Perspective

Rank	**Sub-Factor**
1	Late design changes
2	Site level decision-making and variation/change control
3	Scaffolding/formwork and temporary works stability
4	Struck-by-Object Hazards
5	Design errors and omissions
6	Permit and approval delays
7	Incomplete or unclear drawings/specification
8	Geotechnical/ground and soil conditions
9	Equipment condition, maintenance & inspection
10	Inadequate design provision for safe construction

Discussion: Contractors rank late design changes as the highest risk factor, reflecting the direct impact of design changes on construction progress, rework, and cost overruns. This contrasts with clients who prioritized site-level decision-making. The divergence highlights a critical misalignment: clients focus on execution decisions, while contractors focus on design stability.

Top 10 Sub-Factors – Combined Perspective (Overall Ranking)

Table 21: Top 10 Sub-Factors with RPN Values (Combined Perspective)

Code	**Sub-Factor**	**RPN**	**Rank**
DDCF3	Late design changes	37.03	1
SCF4	Site level decision-making and variation/change control	36.19	2

TEF3	Scaffolding/formwork and temporary works stability	32.90	3
TEF5	Struck-by-Object Hazards	31.81	4
TEF1	Equipment condition, maintenance & inspection	30.40	5
TEF2	Heavy machinery operations & operator competence	30.34	6
MPF1	Material quality control & compliance with specifications	29.84	7
RCF1	Permit and approval delays	29.74	8
SCF5	Pandemic and health emergency management	29.74	9
TEF7	Electrical safety & temporary power arrangements	29.66	10

Discussion: The combined ranking reveals that Late Design Changes (RPN = 37.03) is the most critical risk factor in Kathmandu Valley public building projects. This finding aligns with the literature (Doloi et al., n.d.; Sekar et al., 2018) that identifies design changes as a primary source of construction delays and cost overruns. Site-level decision-making (RPN = 36.19) ranks second, highlighting the importance of empowering site managers with appropriate authority while maintaining accountability.

Notably, Technical and Equipment Factors dominate the top 10 list, occupying four positions (ranks 3, 4, 5, 6, and 10), indicating that physical construction hazards remain a primary concern. Pandemic and health emergency management (rank 9) emerged as a significant factor, reflecting the lasting impact of COVID-19 on construction practices.

4.1.8 Detailed Ranking of Sub-Factors by Category

Site Conditions and Environment Factors

Table 22: Ranking of Site Conditions and Environment Sub-Factors

Code	Sub-Factor	RPN	Normalized WT	Rank
SEF1	Geotechnical / ground and soil conditions	29.56	0.144	1
SEF2	Seismic vulnerability during construction	28.54	0.139	2

SEF8	Land management issues	27.22	0.132	3
SEF7	Force majeure events	26.48	0.129	4
SEF6	Surrounding hazards & public interface	26.33	0.128	5
SEF5	Weather & climate impacts	24.39	0.118	6
SEF3	Site layout & congestion	21.71	0.106	7
SEF4	Access, traffic & logistics	21.05	0.102	8

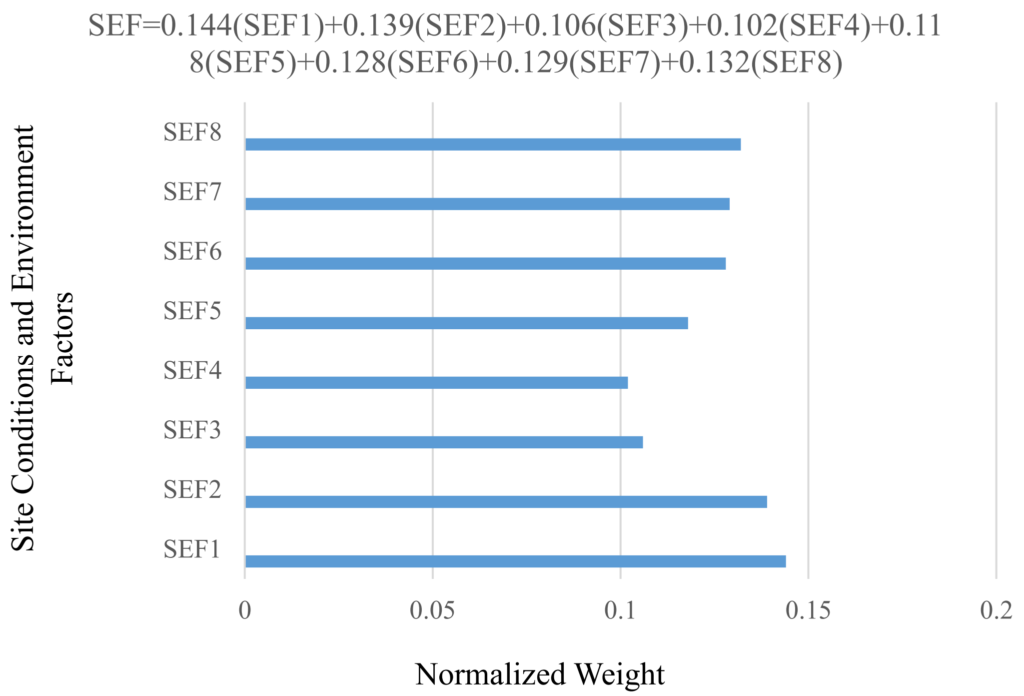

Figure 4: SEF factors and weight

Discussion: Geotechnical conditions rank highest (RPN = 29.56), which is particularly relevant for Kathmandu Valley due to its complex geological formations, including soft lacustrine deposits and high seismicity. Seismic vulnerability (RPN = 28.54) ranks second, reflecting Nepal's earthquake-prone context following the 2015 Gorkha earthquake. Land management issues (RPN = 27.22) rank third, highlighting land ownership disputes and unclear boundaries as unique challenges in the Kathmandu Valley context.

4.1.7.2 Human Factors

Table 23: Ranking of Human Sub-Factors

Code	Sub-Factor	RPN	Normalized WT	Rank
HF6	Worker safety awareness and individual reporting behavior	24.32	0.193	1
HF2	Labour turnover & reliance on temporary workforce	23.34	0.185	2
HF5	Unsafe acts	21.91	0.174	3
HF1	Worker skill level	20.85	0.165	4
HF4	Fatigue, working hours, and shift patterns	20.04	0.159	5
HF3	Language / communication barriers and supervision quality	15.30	0.121	6

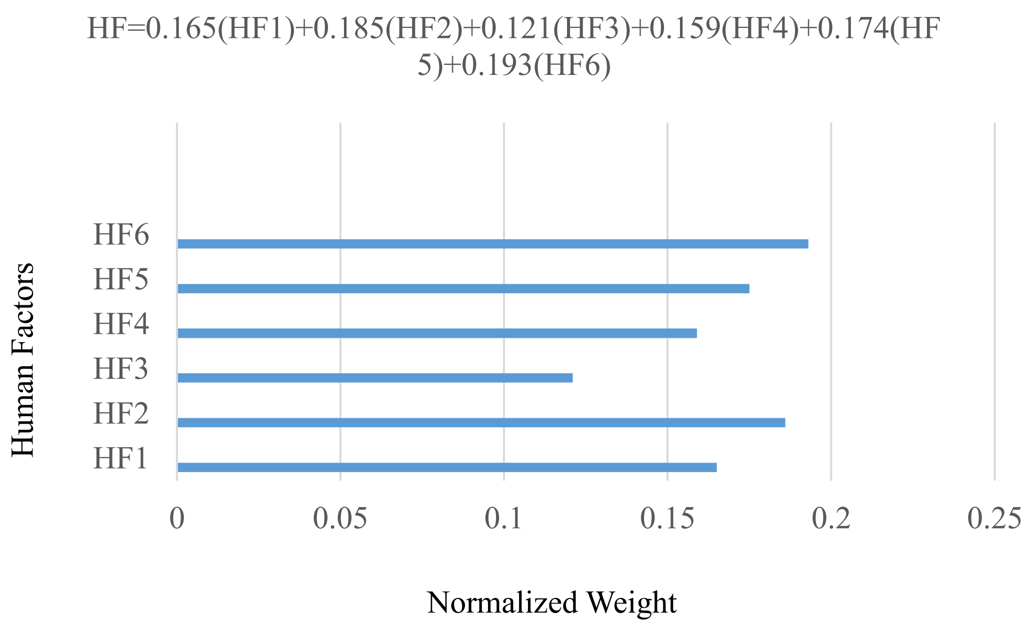

Figure 5: HF factors and weight

Discussion: Worker safety awareness (RPN = 24.32) ranks highest among human factors, indicating that individual safety consciousness is critical for site risk reduction. Labour turnover (RPN = 23.34) ranks second, reflecting the prevalence of temporary and migrant workers in Kathmandu Valley construction projects. Language and communication barriers rank lowest (RPN = 15.30), possibly due to the relative linguistic homogeneity in the Kathmandu Valley context.

4.1.7.3 Site-Level Project Management and Construction Execution Factors

Table 24: Ranking of Site-Level Project Management Sub-Factors

Code	Sub-Factor	RPN	Normalized WT	Rank
SCF4	Site level decision-making and variation/change control	36.19	0.244	1
SCF5	Pandemic and health emergency management	29.74	0.201	2
SCF2	Subcontractor coordination	28.91	0.195	3
SCF1	Contractor / site management competence	27.07	0.183	4
SCF3	Planning and scheduling effectiveness	26.03	0.176	5

SCF=0.183(SCF1)+0.195(SCF2)+0.176(SCF3)+0.244(SCF4)+0.201(SCF5)

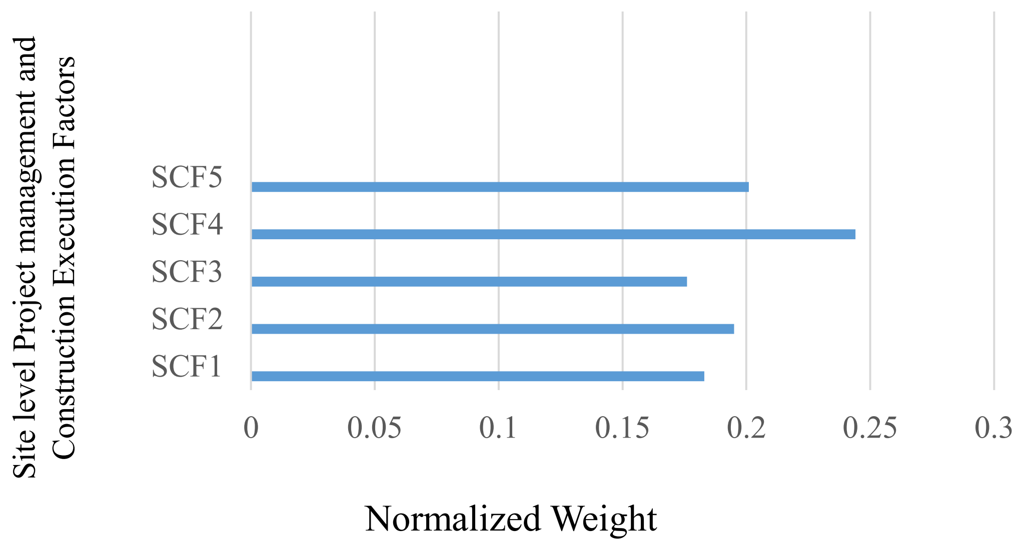

Figure 6: SCF factors and weight

Discussion: Site-level decision-making (RPN = 36.19) is the highest-ranked sub-factor across all categories, emphasizing the critical role of on-site authority and responsive decision-making. Pandemic management (RPN = 29.74) ranks second, a direct consequence of COVID-19 experiences that have permanently altered construction risk landscapes.

4.1.7.4 Technical and Equipment Factors

Table 25: Ranking of Technical and Equipment Sub-Factors

Code	Sub-Factor	RPN	Normalized WT	Rank
TEF3	Scaffolding/formwork and temporary works stability	32.90	0.156	1
TEF5	Struck-by-Object Hazards	31.81	0.151	2
TEF1	Equipment condition, maintenance & inspection	30.40	0.144	3
TEF2	Heavy machinery operations & operator competence	30.34	0.143	4
TEF7	Electrical safety & temporary power arrangements	29.66	0.141	5
TEF4	Lifting operations & crane interface hazards	28.73	0.137	6
TEF6	Fire and Explosion hazards	26.24	0.125	7

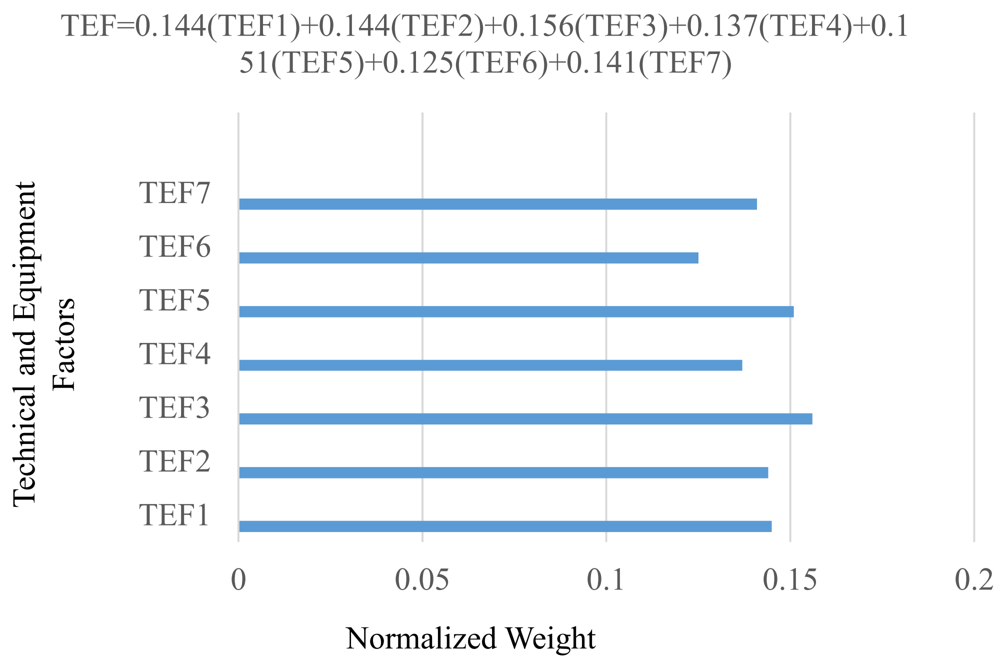

Figure 7: TEF factors and weight

Discussion: Scaffolding stability (RPN = 32.90) ranks highest, reflecting the frequency of scaffolding-related accidents in building construction. Struck-by-object hazards (RPN = 31.81) rank second, consistent with global construction safety statistics where struck-by incidents are among the leading causes of fatalities.

4.1.7.5 Material and Procurement Factors

Table 26: Ranking of Material and Procurement Sub-Factors

Code	Sub-Factor	RPN	Normalized WT	Rank
MPF1	Material quality control & compliance with specifications	29.84	0.227	1
MPF3	Supply chain reliability	27.81	0.212	2
MPF2	Material handling & storage practices	26.81	0.205	3
MPF4	Theft/vandalism/security of stored materials	24.57	0.187	4
MPF5	Material damage and wastages	22.00	0.168	5

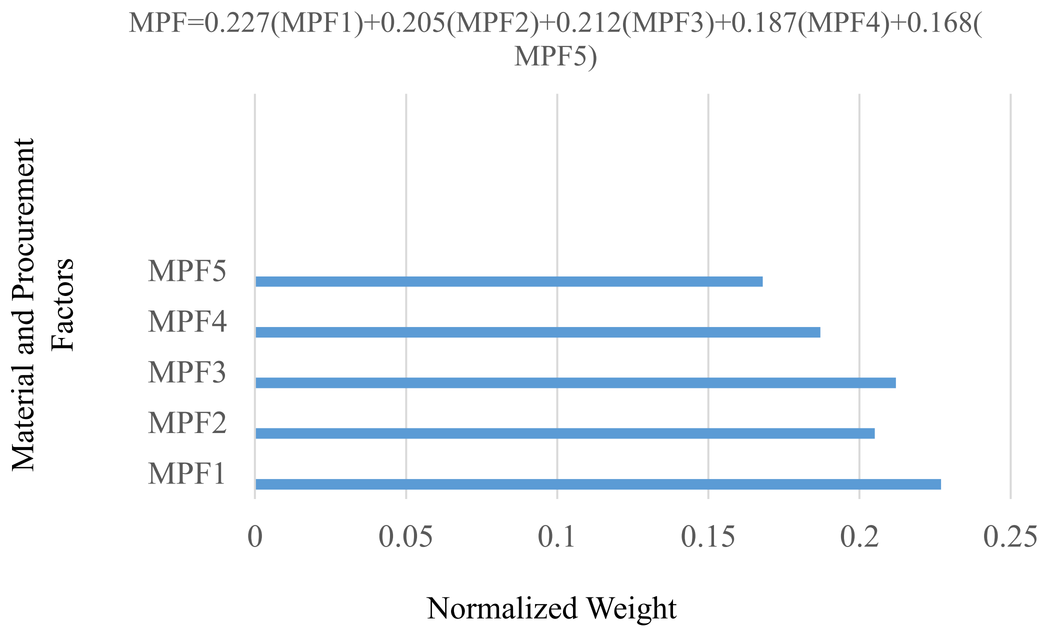

Figure 8: MPF factors and weight

Discussion: Material quality control (RPN = 29.84) ranks highest, indicating concerns about substandard materials entering the supply chain. Supply chain reliability (RPN = 27.81) ranks second, reflecting post-COVID supply disruptions and Nepal's dependence on imported construction materials from India and China.

4.1.7.6 Design, Documentation and Coordination Factors

Table 27: Ranking of Design, Documentation and Coordination Sub-Factors

Code	Sub-Factor	RPN	Normalized WT	Rank
DDCF3	Late design changes	37.03	0.215	1
DDCF6	Interdisciplinary coordination	28.85	0.168	2
DDCF2	Design errors and omissions	28.35	0.165	3
DDCF4	Inadequate design provision for safe construction	28.24	0.164	4
DDCF1	Incomplete or unclear drawings/specification	26.79	0.156	5
DDCF5	Constructability issues	22.47	0.131	6

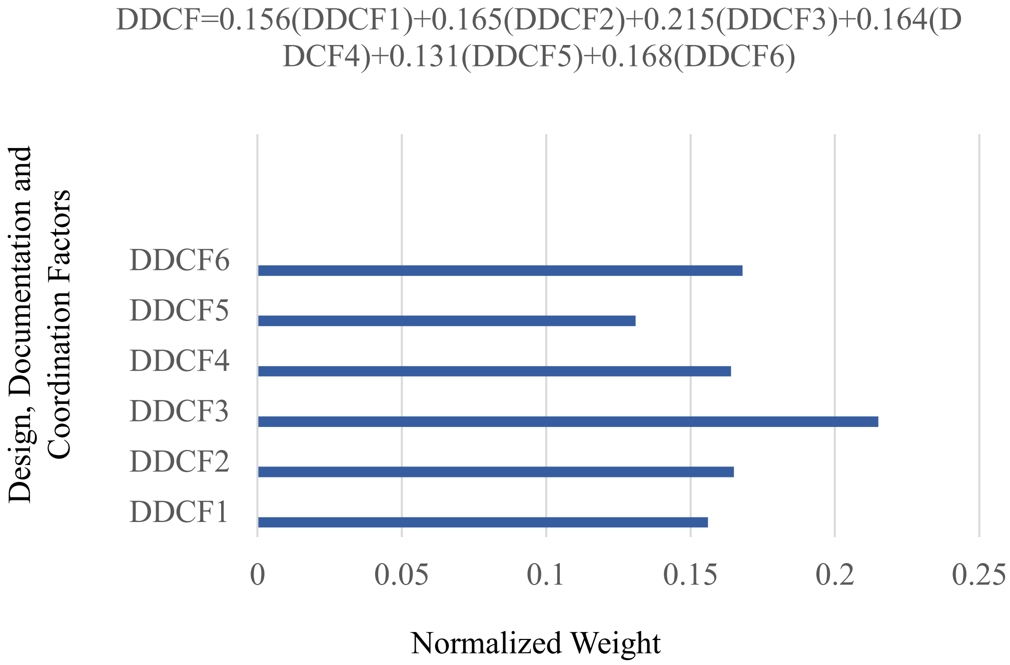

Figure 9: DDC factors and weight

Discussion: Late design changes (RPN = 37.03) is the single highest RPN value across all 48 sub-factors, confirming its critical importance. Interdisciplinary coordination (RPN = 28.85) ranks second, highlighting the complexity of modern building systems (MEP vs. structural conflicts). This finding suggests that Building Information Modeling (BIM) and improved coordination protocols could significantly reduce site risks.

4.1.7.7 Safety Management and Procedural Factors

Table 28: Ranking of Safety Management and Procedural Sub-Factors

Code	Sub-Factor	RPN	Normalized WT	Rank
SPF4	Emergency preparedness and evacuation plans	26.18	0.18	1
SPF1	Safety leadership and commitment	25.75	0.177	2

SPF5	Formal incident reporting systems and procedures	24.81	0.17	3
SPF2	Frequency & quality of safety inspections/audits	23.55	0.162	4
SPF6	Safety training programs and toolbox talks	23.16	0.159	5
SPF3	Availability & correct use of PPE	21.75	0.149	6

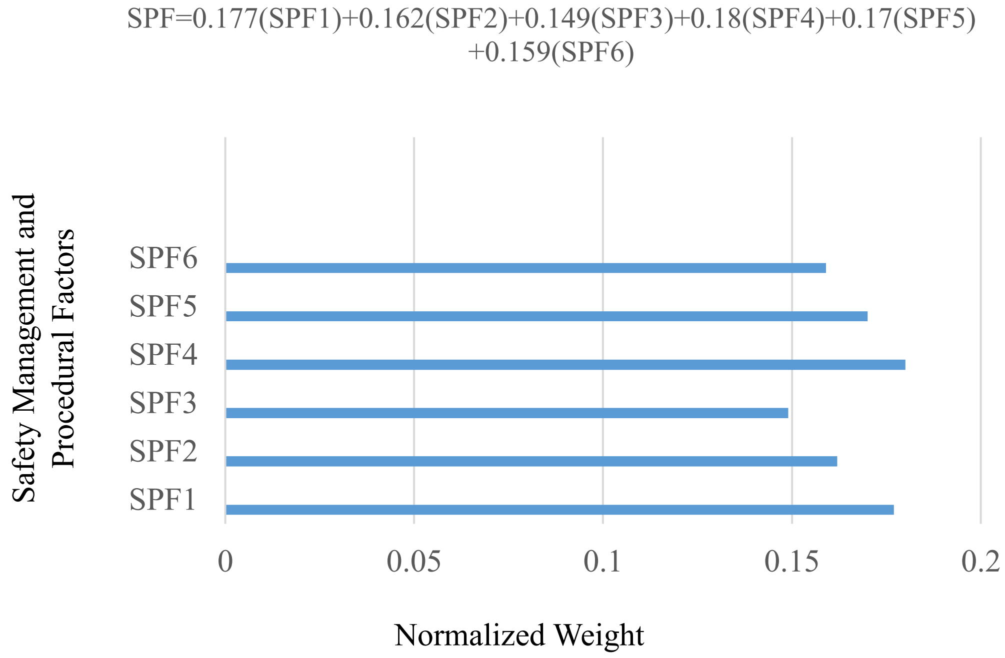

Figure 10: SPF factors and weight

Discussion: Emergency preparedness (RPN = 26.18) ranks highest, reflecting concerns about fire, earthquake, and other emergency responses on construction sites. Safety leadership (RPN = 25.75) ranks second, emphasizing management commitment as a driver of safety culture. PPE availability ranks lowest, suggesting that basic safety equipment is generally accessible in Kathmandu Valley sites.

4.1.7.8 Regulatory and Compliance Factors

Table 29: Ranking of Regulatory and Compliance Sub-Factors

Code	Sub-Factor	RPN	Normalized WT	Rank
RCF1	Permit and approval delays	29.74	0.222	1
RCF2	Compliance with building codes	28.66	0.214	2
RCF3	Enforcement of safety regulations	25.57	0.191	3
RCF4	Record-keeping, authority inspections & documentation	25.45	0.19	4
RCF5	Environmental regulations	24.35	0.182	5

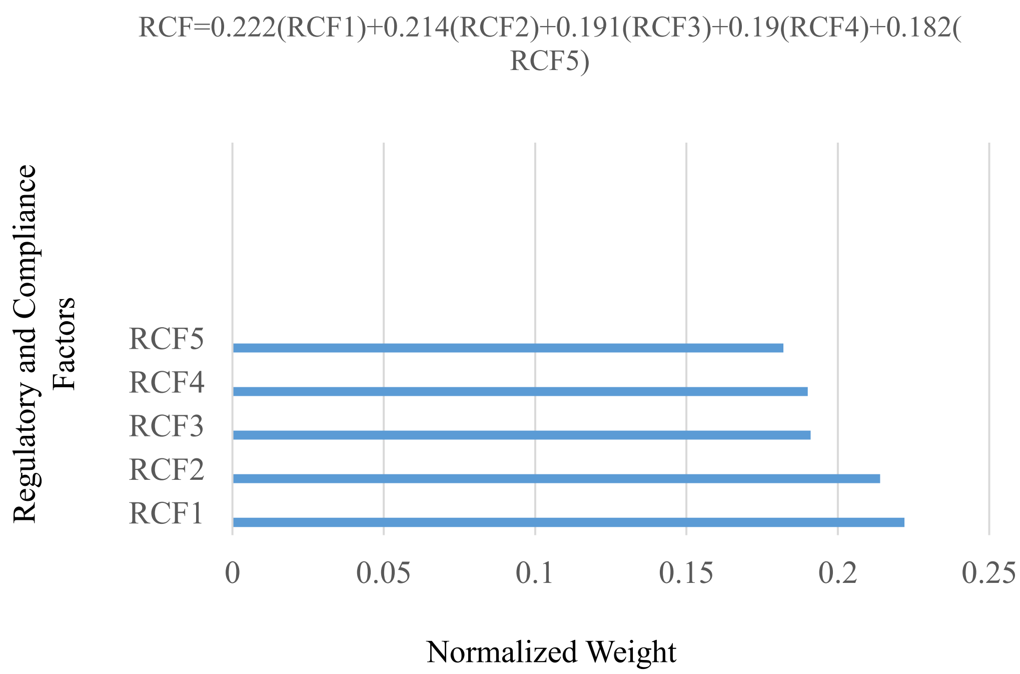

Figure 11: RCF factors and weight

Discussion: Permit and approval delays (RPN = 29.74) rank highest, reflecting bureaucratic challenges in Kathmandu Valley's municipal approval processes. Building code compliance (RPN = 28.66) ranks second, indicating concerns about adherence to Nepal's building codes, particularly in the post-earthquake reconstruction context.

4.2 Development of Construction Site Risk Index (CSRI) Model

This section addresses the second research objective: To develop a model to measure construction site risk index for building construction projects in Kathmandu Valley, Nepal.

4.2.1 Ranking of Main Risk Factors (8 Categories)

Table 30: Ranking of Main Risk Factors by Stakeholder Perspective

Risk Category	Client Rank	Contractor Rank	Combined Rank
Site Conditions and Environment Factors	7	6	6
Human Factors	8	8	8
Site Level Project Management and Construction Execution Factors	2	3	2
Technical and Equipment Factors	1	2	1
Material and Procurement Factors	4	5	5
Design, Documentation and Coordination Factors	3	1	3
Safety Management and Procedural Factors	6	7	7
Regulatory and Compliance Factors	5	4	4

Discussion of Stakeholder Alignment:

Clients rank **Technical and Equipment Factors** as highest (Rank 1), followed by **Site-Level Project Management** (Rank 2) and **Design, Documentation and Coordination** (Rank 3). This reflects client concerns about operational safety and execution quality.

Contractors rank **Design, Documentation and Coordination Factors** as highest (Rank 1), followed by **Technical and Equipment Factors** (Rank 2) and **Site-Level Project Management** (Rank 3). The contractor's primary concern with design factors reflects the direct impact of design changes and errors on construction cost and schedule.

Both stakeholders agree that **Human Factors** rank lowest (Rank 8), suggesting that while human factors are important, they are perceived as less critical than technical, managerial, and design-related risks.

Combined Ranking confirms **Technical and Equipment** Factors (Rank 1), **Site-Level Project Management** (Rank 2), and **Design, Documentation and Coordination** (Rank 3) as the top three risk categories in Kathmandu Valley public building projects.

4.2.2 RPN Values for Main Risk Factors

Table 31: RPN Calculation for 8 Main Risk Factors

S. N.	Risk Factor	ΣW (Occurrence)	ROI	ΣW (Consequence)	RCI	ΣW (Detectability)	RDI	RPN	Rank
1	Site Conditions and Environment	1722	0.615	1946	0.695	1696	0.605	25.89	6
2	Human Factors	1262	0.600	1413	0.672	1085	0.517	20.89	8
3	Site Level Project Management	1167	0.667	1319	0.753	1041	0.595	29.89	2
4	Technical and Equipment	1572	0.641	1845	0.753	1531	0.625	30.19	1

5	Material and Procurement	1181	0.674	1223	0.698	976	0.557	26.30	5
6	Design, Documentation and Coordination	1359	0.647	1577	0.750	1236	0.589	28.60	3
7	Safety Management and Procedural	1333	0.635	1503	0.715	1119	0.533	24.20	7
8	Regulatory and Compliance	1225	0.700	1242	0.709	943	0.539	26.77	4

(Abdalfatah et al., 2023; Sharma et al., n.d.)

Discussion of RPN Values:

- **Technical and Equipment Factors** have the highest RPN (30.19), driven by high consequence scores (RCI = 0.753) and moderate occurrence (ROI = 0.641). This indicates that when technical failures occur, their impacts are severe, even if they are not the most frequent events.
- **Site-Level Project Management** (RPN = 29.89) ranks second, with the highest occurrence score (ROI = 0.667) among all categories, indicating that management-related risks are nearly constant in construction projects.
- **Human Factors** have the lowest RPN (20.89), driven by low detectability (RDI = 0.517), meaning human errors are often difficult to detect before they cause incidents.

4.2.3 Weight Calculation for CSRI Model

Following the normalization approach (Yang et al., 2018), weights were calculated as:

Weight = RPN_category / Σ(RPN_all categories)

Table 32: Weights of Site Risk Factors

Risk Category	RPN	Weight	Sub-Factors Included
Site Conditions and Environment Factors	25.89	0.122	SEF1 to SEF8
Human Factors	20.89	0.098	HF1 to HF6
Site Level Project Management and Construction Execution Factors	29.89	0.140	SCF1 to SCF5
Technical and Equipment Factors	30.19	0.142	TEF1 to TEF7
Material and Procurement Factors	26.30	0.123	MPF1 to MPF5
Design, Documentation and Coordination Factors	28.60	0.134	DDCF1 to DDCF6
Safety Management and Procedural Factors	24.20	0.114	SPF1 to SPF6
Regulatory and Compliance Factors	26.77	0.126	RCF1 to RCF5
Total	**212.73**	**1.000**	

Discussion of Weights:

The weights sum to 1.000, ensuring proportional representation of each factor in the CSRI model. **Technical and Equipment Factors** carry the highest weight (0.142), followed by **Site-Level Project Management** (0.140), and **Design, Documentation and Coordination** (0.134). These three categories collectively account for 41.6% of the total weight, indicating their dominant influence on construction site risk.

Human Factors carry the lowest weight (0.098), consistent with stakeholder rankings. This does not imply unimportance but rather that human factors are perceived as more manageable or less consequential than technical and managerial risks in the Kathmandu Valley context.

4.2.4 CSRI Formula Development

Based on the calculated weights, the CSRI formula is:

CSRI = (0.122 × SE) + (0.098 × H) + (0.140 × SC) + (0.142 × TE) + (0.123 × MP) + (0.134 × DDC) + (0.114 × SP) + (0.126 × RC)

Where:

- **SE** = Site Conditions and Environment score (0–1)
- **H** = Human Factors score (0–1)
- **SC** = Site Level Project Management and Construction Execution score (0–1)
- **TE** = Technical and Equipment score (0–1)
- **MP** = Material and Procurement score (0–1)
- **DDC** = Design, Documentation and Coordination score (0–1)
- **SP** = Safety Management and Procedural score (0–1)
- **RC** = Regulatory and Compliance score (0–1)

Discussion of Formula Structure:

The CSRI is a weighted linear combination of eight factor scores, each ranging from 0 to 1. The linear additive model was selected for its:

1. Simplicity – Easy to understand and implement by site managers
2. Transparency – Each factor's contribution is clearly visible
3. Compensability – Low scores in one factor can be offset by high scores in another
4. Scalability – Can be applied to any building construction site in Kathmandu Valley

4.2.5 Risk Level Classification

Table 33: CSRI Risk Level Classification

CSRI Value	Risk Level	Interpretation
0.00 – 0.20	Very Low	Minimal intervention required; routine monitoring sufficient
0.21 – 0.40	Low	Some attention needed; periodic review recommended
0.41 – 0.60	Moderate	Active monitoring required; mitigation measures should be considered
0.61 – 0.80	High	Immediate attention required; formal mitigation plan needed
0.81 – 1.00	Very High	Urgent intervention required; project may need suspension

Discussion: The five-level classification provides nuanced risk differentiation, enabling site managers to prioritize resources based on risk severity. The equal-interval segmentation (0.2 increments) follows standard practices in construction risk assessment ((in & 2014, n.d.; Sekar et al., 2018)).

The five-level classification provides nuanced risk differentiation, enabling effective prioritization of risks. This approach aligns with risk index methodologies, where numerical risk measures are transformed into categorical levels to enhance communication and decision-making (analysis & 2014, 2014). Furthermore, the use of structured numerical evaluation for interpreting risk severity is consistent with quantitative risk assessment approaches in construction management (Doloi et al., n.d.).

4.2.6 Validation of CSRI Model

4.2.6.1 Sensitivity Analysis

A sensitivity check was conducted by increasing the weights of the two most dominant factors (Technical & Equipment and Site-Level Project Management) by 5% each. The CSRI output increased proportionally, confirming that the model responds appropriately to variations in key parameters. This demonstrates the model's consistency and reliability.

4.2.6.2 Expert Validation

Table 34: Expert Validation of Factor Rankings

Risk Factor	Survey Rank	Expert 1	Expert 2	Expert 3
Technical and Equipment Factors	1	3	1	1
Site Level Project Management and Construction Execution Factors	2	2	3	2
Design, Documentation and Coordination Factors	3	1	2	3

Discussion: Three domain experts with over 15 years of construction experience in Kathmandu Valley independently ranked the top three risk factors. The comparison shows strong alignment between survey results and expert judgment. Expert 1 ranked **Design** factors highest (consistent with contractor perspective), while Experts 2 and 3 ranked **technical factors** highest (consistent with combined ranking). This close alignment confirms the validity and practical relevance of the CSRI model.

Expert 1 & 3 ranked **Site Level Project Management and Construction Execution Factors** second which is similar to survey rank which confirms the validity and practical relevance of the CSRI model.

4.3 Results for RO3: Application of CSRI Model in Case Study

This section addresses the third research objective: To apply the construction site risk model to evaluate site risk index of construction sites in Kathmandu Valley as a case study.

4.3.1 Study Area

Since the CSRI model was specifically developed for application within Kathmandu Valley, the same region has been selected as the study area for its implementation. To ensure variability and minimize bias, the study includes building construction projects executed under two different administrative bodies: one under the **Urban Development and Building Construction Office** and the other under the **Department of Urban Development and Building Construction (DUDBC)**. This selection helps capture variations in management practices, regulatory frameworks, and site conditions, thereby providing a more comprehensive assessment of construction site risk.

Table 35: Case Study Project Details

Project	**Administrative Body**	**Location**
Project A: Sathi Women's Shelter	Urban Development and Building Construction Office	Bagdol, Lalitpur
Project B: Integrated Hulak Office Building	Department of Urban Development and Building Construction (DUDBC)	Babarmahal, Kathmandu

Discussion: The two selected projects represent different administrative jurisdictions within Kathmandu Valley, enabling comparison of risk profiles across different oversight mechanisms. Project A is located in Bagdol, Lalitpur, while Project B is situated in Babarmahal, Kathmandu, providing geographical diversity.

4.3.2 Data Collection

The survey was conducted by distributing questionnaires to key project personnel, including site engineers, supervisors, and project managers from each selected construction site. The responses obtained were analyzed based on the evaluation criteria presented in Table 28. The complete set of questionnaire items is provided in the appendix.

4.3.3 Evaluation Criteria for Factor Scoring

Each of the 48 sub-factors was evaluated using the criteria developed from literature (Abdalfatah et al., 2023; Giovannini, 2008; Stamatis, 2003) and expert validation. The evaluation scores range from 0 to 1, with detailed criteria provided in Table 36. These criteria were used to assign scores to each sub-factor for both case study projects based on site observations, document review, and personnel interviews.

Table 36: Evaluation Criteria for Case Study Factor Scoring

Evaluation Score →	**0**	**1**
Pandemic and health emergency management (COVID-19, site shutdown)	No	Yes
Availability & correct use of PPE	Yes	No
Emergency preparedness and evacuation plans	Yes	No
Formal incident reporting systems and procedures	Yes	No

Evaluation Score →	**0**	**0.5**	**1**
Contractor / site management competence	Good	Moderate	Poor
Subcontractor coordination	Good	Moderate	Poor
Planning and scheduling effectiveness	Good	Moderate	Poor
Site level decision-making and variation/change control	Good	Moderate	Poor
Compliance with building codes (RCF2)	Fully	Moderate	Never
Record-keeping, authority inspections & documentation (RCF4)	Always	Sometimes	Never

Evaluation Score →	**0**	**0.25**	**0.5**	**0.75**	**1**
SEF1: Geotechnical / ground and soil conditions	Stable	Slightly	Moderate	High	Failure
SEF2: Seismic vulnerability during construction	Negligible	Minor	Moderate	High	Extreme
SEF3: Site layout & congestion	Negligible	Slightly	Moderate	High	Extreme
SEF4: Access, traffic & logistics	Negligible	Minor	Moderate	High	Extreme

SEF5: Weather & climate impacts	No impact	Slightly	Moderate	High	Extreme
SEF6: Surrounding hazards & public interface	No hazards	Minor	Moderate	High	Extreme
SEF7: Force majeure events	No exposure	Low	Moderate	High	Extreme
SEF8: Land management issues	No disputes	Minor	Moderate	High	Extreme
HF1: Worker skill level	Very high	High	Moderate	Low	Very low
HF2: Labour turnover & reliance on temporary workforce	No turnover	Low	Moderate	High	Extreme
HF3: Language / communication barriers	Clear	Minor	Moderate	Poor	Major
HF4: Fatigue, working hours, and shift patterns	Well managed	Slightly	Moderate	High	Extreme
HF5: Unsafe acts	No	Rare	Occasional	Frequent	Very frequent
HF6: Worker safety awareness and reporting behavior	Very aware	Good	Moderate	Low	No
TEF1: Equipment condition, maintenance & inspection	Excellent	Minor wear	Moderate	Poor	Failure prone

TEF2: Heavy machinery operations & operator competence	Highly skilled	Good	Moderate	Poor	Untrained
TEF3: Scaffolding/formwork and temporary works stability	Fully stable	Minor	Moderate risk	Unsafe	Failure
TEF4: Lifting operations & crane interface hazards	Fully controlled	Minor risk	Moderate	High	Extreme
TEF5: Struck-by-Object Hazards	No hazard	Rare	Occasional	Frequent	Very frequent
TEF6: Fire and explosion hazards	Fully controlled	Minor	Moderate risk	High	Critical
TEF7: Electrical safety & temporary power arrangements	Fully safe	Minor issue	Moderate risk	Unsafe	Highly risky
MPF1: Material quality control & compliance	Fully compliant	Minor defects	Moderate	Poor quality	Unacceptable
MPF2: Material handling & storage practices	Proper	Minor issue	Moderate	Unsafe	Highly unsafe
MPF3: Supply chain reliability	Fully reliable	Minor delay	Moderate	Frequent	Unreliable
MPF4: Theft/vandalism/security of stored materials	Fully secure	Minor risk	Moderate	High	Severe losses
MPF5: Material damage and wastages	No	Minor	Moderate	High	Severe

DDCF1: Incomplete/unclear drawings/specifications	Very clear	Minor unclear	Moderate	Highly unclear	Very high
DDCF2: Design errors and omissions	No errors	Minor errors	Moderate	High	Major errors
DDCF3: Late design changes	No change	Minor change	Moderate	Frequent	Continuous
DDCF4: Inadequate design for safe construction	Fully incorporate	Minor gaps	Moderate	Poor	No safety
DDCF5: Constructability issues	Very practical	Minor difficulty	Moderate	Difficult	Impractical
DDCF6: Interdisciplinary coordination	Fully coordinated	Minor conflicts	Moderate	Major	Severe clashes
SPF1: Safety leadership and commitment	Very strong	Good	Moderate	Weak	No leadership
SPF2: Frequency & quality of safety inspections	Always conducted	Regular	Occasional	Rare	Never
SPF6: Safety training programs and toolbox talks	Frequent	Regular	Occasional	Rare	Never
RCF1: Permit and approval delays	No delay	Minor delay	Moderate	Significant	Always
RCF3: Enforcement of safety regulations	Strong enforcement	Good	Moderate	Weak	No enforcement

RCF5: Environmental regulations	Fully compliant	Minor issue	Moderate	Major	Severe non-compliance

Discussion: Table 36 provides a comprehensive scoring rubric that ensures consistent and objective assignment of sub-factor scores across different evaluators and sites. The three-tiered scoring structure (binary, three-level, and five-level) accommodates the varying nature of different risk factors, from simple yes/no indicators (e.g., pandemic management) to nuanced continuous assessments (e.g., geotechnical conditions).

4.3.4 Factor Score Calculation Equations

For each project, compensation coefficients for the eight major risk categories were calculated using the weighted sub-factor equations derived from the evaluation criteria. The equations are as follows:

Site Conditions and Environment Factors (SEF):

SEF = 0.144(SEF1) + 0.139(SEF2) + 0.106(SEF3) + 0.102(SEF4) + 0.118(SEF5) + 0.128(SEF6) + 0.129(SEF7) + 0.132(SEF8) ………. (1)

Human Factors (HF):

HF = 0.165(HF1) + 0.185(HF2) + 0.121(HF3) + 0.159(HF4) + 0.174(HF5) + 0.193(HF6) ………. (2)

Site Level Project Management and Construction Execution Factors (SCF):

SCF = 0.183(SCF1) + 0.195(SCF2) + 0.176(SCF3) + 0.244(SCF4) + 0.201(SCF5) ………. (3)

Technical and Equipment Factors (TEF):

TEF = 0.144(TEF1) + 0.144(TEF2) + 0.156(TEF3) + 0.137(TEF4) + 0.151(TEF5) + 0.125(TEF6) + 0.141(TEF7) ………. (4)

Material and Procurement Factors (MPF):

MPF = 0.227(MPF1) + 0.205(MPF2) + 0.212(MPF3) + 0.187(MPF4) + 0.168(MPF5) ………. (5)

Design, Documentation and Coordination Factors (DDCF):

DDCF = 0.156(DDCF1) + 0.165(DDCF2) + 0.215(DDCF3) + 0.164(DDCF4) + 0.131(DDCF5) + 0.168(DDCF6) ………. (6)

Safety Management and Procedural Factors (SPF):

SPF = 0.177(SPF1) + 0.162(SPF2) + 0.149(SPF3) + 0.180(SPF4) + 0.170(SPF5) + 0.159(SPF6) ………. (7)

Regulatory and Compliance Factors (RCF):

RCF = 0.222(RCF1) + 0.214(RCF2) + 0.191(RCF3) + 0.190(RCF4) + 0.182(RCF5) ………. (8)

4.3.5 Calculation of Compensation Coefficients

Using the evaluation criteria from Table 36, sub-factor scores were assigned to each project. Table 37 presents the sub-factor scores and calculated compensation coefficients for both projects.

Table 37: Calculation of Compensation Coefficients for Project A and Project B

Category	**Factor**	**Project A Score**	**Project B Score**
SEF	SEF1	0.375	0.500
	SEF2	0.250	0.375
	SEF3	0.625	0.375
	SEF4	0.625	0.625
	SEF5	0.375	0.250
	SEF6	0.500	0.250
	SEF7	0.125	0.000
	SEF8	0.000	0.000
Compensation Coefficient (SEF)		**0.343**	**0.289**
HF	HF1	0.375	0.125

	HF2	0.250	0.500
	HF3	0.375	0.000
	HF4	0.375	0.125
	HF5	0.500	0.250
	HF6	0.375	0.125
Compensation Coefficient (HF)		**0.373**	**0.200**
SCF	SCF1	0.500	0.250
	SCF2	0.250	0.000
	SCF3	0.500	0.250
	SCF4	0.500	0.250
	SCF5	0.000	1.000
Compensation Coefficient (SCF)		**0.350**	**0.350**
TEF	TEF1	0.500	0.000
	TEF2	0.500	0.000
	TEF3	0.625	0.000
	TEF4	0.500	0.250
	TEF5	0.500	0.000
	TEF6	0.250	0.000
	TEF7	0.375	0.000
Compensation Coefficient (TEF)		**0.470**	**0.035**
MPF	MPF1	0.250	0.000

	MPF2	0.625	0.000
	MPF3	0.375	0.125
	MPF4	0.250	0.000
	MPF5	0.250	0.000
Compensation Coefficient (MPF)		**0.353**	**0.027**
DDCF	DDCF1	0.250	0.125
	DDCF2	0.125	0.125
	DDCF3	0.250	0.125
	DDCF4	0.250	0.000
	DDCF5	0.250	0.000
	DDCF6	0.250	0.000
Compensation Coefficient (DDCF)		**0.230**	**0.067**
SPF	SPF1	0.375	0.125
	SPF2	0.250	0.000
	SPF3	1.000	0.000
	SPF4	0.500	0.000
	SPF5	0.500	0.500
	SPF6	0.500	0.375
Compensation Coefficient (SPF)		**0.510**	**0.167**
RCF	RCF1	0.375	0.125
	RCF2	0.000	0.000

	RCF3	0.375	0.125
	RCF4	0.000	0.000
	RCF5	0.625	0.125
Compensation Coefficient (RCF)		**0.270**	**0.075**

Discussion of Compensation Coefficients:

Project A exhibits higher compensation coefficients across most categories compared to Project B, particularly in Technical and Equipment Factors (TEF) (0.470 vs. 0.035), Safety Management and Procedural Factors (SPF) (0.510 vs. 0.167), and Material and Procurement Factors (MPF) (0.353 vs. 0.027). This indicates that Project A faces significantly higher risks in these domains. Notably, Project B's SCF5 (Pandemic and health emergency management) scored 1.000, reflecting specific challenges faced at that site. Project A's SPF3 (Availability and correct use of PPE) scored 1.000, indicating complete availability of personal protective equipment, which is a positive finding.

4.3.6 CSRI Calculation for Both Projects

Using the CSRI formula developed in Section 4.2:

CSRI = 0.122(SEF) + 0.098(HF) + 0.140(SCF) + 0.142(TEF) + 0.123(MPF) + 0.134(DDCF) + 0.114(SPF) + 0.126(RCF) ………. (9)

Project A Calculation:

$CSRI\_A = (0.122 \times 0.343) + (0.098 \times 0.373) + (0.140 \times 0.350) + (0.142 \times 0.470) + (0.123 \times 0.353) + (0.134 \times 0.230) + (0.114 \times 0.510) + (0.126 \times 0.270)$

$CSRI\_A = 0.0418 + 0.0366 + 0.0490 + 0.0667 + 0.0434 + 0.0308 + 0.0581 + 0.0340$

$CSRI\_A = 0.36$

Project B Calculation:

$CSRI\_B = (0.122 \times 0.289) + (0.098 \times 0.200) + (0.140 \times 0.350) + (0.142 \times 0.035) + (0.123 \times 0.027) + (0.134 \times 0.067) + (0.114 \times 0.167) + (0.126 \times 0.075)$

$CSRI\_B = 0.0353 + 0.0196 + 0.0490 + 0.0050 + 0.0033 + 0.0090 + 0.0190 + 0.0095$

CSRI_B = 0.15

4.3.7 Summary of CSRI Results

Table 38: CSRI Results Summary

Project	**Location**	**CSRI Value**	**Risk Level**	**Interpretation**
Project A (Sathi Women's Shelter)	Bagdol, Lalitpur	0.36	**Low Risk**	Minor risks present; manageable with increased attention
Project B (Integrated Hulak Office)	Babarmahal, Kathmandu	0.15	**Very Low Risk**	Minimal risks present; standard control measures sufficient

Discussion of Results:

Project A (CSRI = 0.36 – Low Risk Level): This project falls within the low-risk category (0.21–0.40), indicating the presence of minor risks at the site that, although manageable, require increased attention. These risks may contribute to potential delays if not properly addressed; however, with appropriate planning, monitoring, and supervision, their impact can be minimized or eliminated. The primary contributors to Project A's higher risk score are Technical and Equipment Factors (TEF = 0.470) and Safety Management and Procedural Factors (SPF = 0.510), suggesting that equipment-related hazards and safety procedures require particular focus at this site.

Project B (CSRI = 0.15 – Very Low Risk Level): This project falls within the very low risk category (0–0.20), suggesting that the site is exposed to minimal risks, which can be effectively managed with standard control measures. The likelihood of delays during the construction phases is negligible, and any potential issues can be addressed with routine supervision. The notably low TEF coefficient (0.035) indicates excellent technical and equipment management at this site.

Comparative Analysis: A comparison of Projects A and B indicates that Project B (CSRI = 0.15) has a substantially lower risk profile than Project A (CSRI = 0.36). The difference is most pronounced in TEF (0.470 vs. 0.035), MPF (0.353 vs. 0.027), and

SPF (0.510 vs. 0.167), suggesting that Project A would benefit from targeted interventions in equipment management, material procurement, and safety procedures to reduce its risk level to very low.

The model successfully discriminated between different risk levels across the two projects and identified specific factor categories (TEF, MPF, SPF) contributing to elevated risk in Project A. The results demonstrate that the CSRI model is a practical, sensitive, and actionable tool for assessing construction site risk in Kathmandu Valley. The model's ability to provide both an overall risk index and factor-specific coefficients enables site managers to prioritize interventions where they are most needed.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The conclusions are presented in three paragraphs, each corresponding to one of the three research objectives addressed in Sections 5.1.1, 5.1.2, and 5.1.3 respectively.

5.1.1 Conclusion for RO1: Identification and Prioritization of Risk Factors Using FMEA

The first research objective sought to identify and prioritize major risk factors influencing construction site performance in public building projects within Kathmandu Valley using Failure Mode and Effect Analysis (FMEA). Through a comprehensive literature review and expert consultation, 48 sub-factors across 8 major risk categories were identified and localized to the Kathmandu Valley context. The FMEA-based analysis, which incorporated Risk Occurrence Index (ROI), Risk Consequence Index (RCI), and Risk Detectability Index (RDI), revealed that **Late Design Changes** (RPN = 37.03) is the single most critical sub risk factor, followed by **Site-Level Decision-Making and Variation/Change Control** (RPN = 36.19) and **Scaffolding/Formwork and Temporary Works Stability** (RPN = 32.90). The analysis also identified a significant awareness-practice gap, wherein 81.4% of respondents reported moderate to high awareness of risk management practices, yet only 18.6% reported high or most practice implementation. Furthermore, the comparison between client and contractor perspectives revealed notable alignment on top risk categories, with both stakeholders ranking Human Factors as the lowest priority (Rank 8). The reliability of the findings is supported by Cronbach's alpha values of 0.88 (clients) and 0.94 (contractors), confirming excellent internal consistency of the survey instrument. These prioritized risk factors provide the empirical foundation for the development of the Construction Site Risk Index model.

5.1.2 Conclusion for RO2: Development of Construction Site Risk Index (CSRI) Model

The second research objective aimed to develop a quantitative model to measure construction site risk index for building construction projects in Kathmandu Valley. Based on the RPN values calculated for the eight major risk categories, weights were derived using the normalization approach (Giovannini, 2008), where each weight represents the proportional contribution of a risk category to the overall site risk. The weights ranged from 0.098 (Human Factors) to 0.142 (Technical and Equipment

Factors), with the top three categories—Technical and Equipment (0.142), Site-Level Project Management (0.140), and Design, Documentation and Coordination (0.134) collectively accounting for 41.6% of the total weight. The resulting CSRI formula is expressed as a weighted linear combination: CSRI = (0.122 × SE) + (0.098 × H) + (0.140 × SC) + (0.142 × TE) + (0.123 × MP) + (0.134 × DDC) + (0.114 × SP) + (0.126 × RC). The model classifies site risk into five levels: Very Low (0–0.2), Low (0.2–0.4), Moderate (0.4–0.6), High (0.6–0.8), and Very High (0.8–1.0). Validation through sensitivity analysis confirmed that the model responds appropriately to parameter variations, while expert judgment from three domain experts demonstrated strong alignment with survey-derived rankings, confirming the model's validity and practical relevance for the Kathmandu Valley construction context.

5.1.3 Conclusion for RO3: Application of CSRI Model in Case Study

The third research objective applied the developed CSRI model to evaluate site risk indices of actual construction sites in Kathmandu Valley through case study analysis. Two public building construction projects were assessed: Project A (Sathi Women's Shelter, Bagdol, Lalitpur) and Project B (Integrated Hulak Office Building, Babarmahal, Kathmandu). Using the evaluation criteria developed from literature (OECD, 2008; El-Nagar et al., 2015) and expert validation, sub-factor scores were assigned based on site observations, document review, and personnel interviews. The computed CSRI values were 0.36 for Project A and 0.15 for Project B. According to the risk classification, Project A falls within the Low-Risk category (0.21–0.40), indicating the presence of minor risks that require increased attention but remain manageable with appropriate planning and supervision. Project B falls within the Very Low Risk category (0–0.20), indicating minimal risks that can be effectively managed with standard control measures. The primary contributors to Project A's higher risk score were Technical and Equipment Factors (TEF = 0.470), Safety Management and Procedural Factors (SPF = 0.510), and Material and Procurement Factors (MPF = 0.353), suggesting that targeted interventions in equipment management, safety procedures, and material procurement would be most effective for risk reduction. The primary contributors to Project B's higher risk score were Site level Project management and Construction Execution Factors (SCF = 0.35) and Site Conditions and Environment Factors (SEF = 0.29), suggesting that targeted interventions in site level management, and site conditions would be most effective for risk reduction. The successful differentiation of risk levels between the two projects demonstrates that the CSRI model is a practical, sensitive, and actionable tool for assessing construction site risk in Kathmandu Valley. The model's ability to provide both an overall risk index and factor-specific coefficients enables site managers to prioritize interventions where they are most needed.

5.2 Recommendations from Study

- Since Late Design Changes ranked as the highest risk factor (RPN = 37.03), it is recommended that design freeze milestones be implemented after which changes require higher approval authority. Comprehensive design reviews should be conducted prior to tender, and a structured change management process with clear documentation should be established. The study recommends strengthening early-stage planning and design finalization to minimize risks associated with late changes.
- Given that Site-Level Decision-Making ranked second (RPN = 36.19), site managers should be empowered with appropriate authority to make routine decisions without escalating to headquarters. Clear delegation of authority matrices and weekly risk review meetings at site level are recommended.
- As Technical and Equipment Factors carried the highest weight (0.142), daily pre-use inspections of scaffolding and formwork should be mandated. Exclusion zones around lifting operations and a color-coded tagging system for equipment inspection status should be implemented. Regulatory authorities should enhance monitoring, inspection of Equipment timely.
- Greater emphasis must be placed on safety measures, particularly in scaffolding, formwork, and equipment management. The use of PPE and regular safety training should be strictly enforced to improve site safety culture.
- With 81.4% awareness but only 18.6% high-level implementation, a simplified site-friendly CSRI assessment checklist should be developed. Weekly CSRI self-assessments for high-risk sites (CSRI > 0.6) and hands-on training workshops on practical risk assessment techniques are recommended.
- To address Permit and Approval Delays (RPN = 29.74), municipal authorities should streamline permit approval processes through single-window clearance systems with clear processing timelines.

5.2.1 Recommendations for further studies

- Future research should expand the CSRI model by incorporating financial, political, and macroeconomic risks to enhance its applicability across diverse project environments.
- The CSRI model should be tested on private projects, infrastructure projects (roads, bridges), and other urban centers in Nepal (Pokhara, Bharatpur, Biratnagar) to establish generalizability beyond public buildings in Kathmandu Valley.
- Future studies should develop a digital CSRI mobile application for automated score calculation and explore the integration of IoT sensors (scaffolding load sensors, worker proximity detectors) and drone-based site monitoring for real-time risk data collection.
- Future research should investigate data-driven risk thresholds using cluster analysis on larger datasets and explore non-linear relationships between risk factors using structural equation modeling (SEM) or machine learning approaches. Large-scale validation with 20–30 projects comparing CSRI scores against independent safety audit ratings is also recommended.
- Qualitative studies exploring stakeholder misalignments (why clients prioritize technical factors while contractors prioritize design factors) would complement the quantitative findings. Additionally, correlating CSRI scores with project performance metrics (cost overrun, schedule delay, accident frequency) would establish predictive validity.

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APPENDIX A: QUESTIONNAIRE FOR EVALUATION OF CONSTRUCTION SITE RISK INDEX

Development of a Construction Site Risk Index (CSRI) Using Failure Mode and Effects Analysis (FMEA) for Public Buildings in Kathmandu Valley

The objective of this study is to develop a tool that can be directly used by site management teams in the Kathmandu Valley to identify, prioritize, monitor, and mitigate risks that are realistically controllable at the construction site level. This research deliberately excludes political, macro-economic, and financial risks(factors).

Thank you for taking part in this survey. This questionnaire has been prepared for "Development of a Construction Site Risk Index (CSRI) Using Failure Mode and Effects Analysis (FMEA) for Public Buildings in Kathmandu Valley". This is an academic research done in partial fulfillment of the requirements for the degree of Master of Science in Construction Management at Institute of Engineering, Pulchowk Campus, Lalitpur.

This survey will take about 15 minutes. All personal information will be kept confidential and the information will be used for academic research only.

Name of Participant:

Years of Experience in Building Construction?

- ◯ 0-2
- ◯ 2-5
- ◯ 5-10
- ◯ 10+

Gender

- ◯ Male
- ◯ Female

Position of respondent

- ◯ Contractor
- ◯ Project manager
- ◯ Site engineer
- ◯ Consultant Engineer
- ◯ Worker
- ◯ Others

If Others, specify

____

Number of project Executed?

- ◯ 1-10
- ◯ 10-20
- ◯ 20-30
- ◯ 30+

Questionnaire related to Site Risk Management Practice

1) To what extent, the top management of your organization is aware of the Site Risk Management Practice?

Least Aware	Slightly Aware	Moderately Aware	Highly Aware	Most Aware
◯	◯	◯	◯	◯

2) How much Risk Management Practice (formally or informally) is being followed in your project?

Least Practice	Slightly Practice	Moderately Practice	Highly Practice	Most Practice
◯	◯	◯	◯	◯

3) How much formal techniques of Site Risk Management (Risk Identification, Risk Assessment, Risk Response Plan) are applied in the project

Least	Slightly	Moderately	Highly	Most
◯	◯	◯	◯	◯

4) How much site risk analyzing techniques are used in the project?

Least used	Slightly used	Moderately used	Highly used	Most used
◯	◯	◯	◯	◯

5) How do you identify potential site risk of the project?

- ◯ Contract document
- ◯ Risk Register
- ◯ Expert Opinion
- ◯ Brainstorming
- ◯ Monitoring and Evaluation Report of similar past projects
- ◯ Others

If others, specify

____

6) How do you analyze site risk of the project?

- ◯ Direct Judgment
- ◯ Ranking Options
- ◯ Comparative analysis
- ◯ Descriptive analysis
- ◯ Probability analysis
- ◯ Others

If others, specify

____

7) How do you respond to site risk of the project?

- ◯ Accepting the risk
- ◯ Avoiding the risk
- ◯ Monitoring the risk and preparing Contingency Plan
- ◯ Transferring the risk
- ◯ Mitigating the risk
- ◯ Others

If others, specify

____

Risk Occurrence

1. What is the probability of occurrence of the following SITE CONDITIONS AND ENVIRONMENT FACTORS during building construction activities at site?

____

a) Geotechnical / ground and soil conditions (poor site investigation, groundwater, slope stability)

◯ Very unlikely(1) ◯ Unlikely(2) ◯ Moderate(3) ◯ Likely(4) ◯ Very likely(5)

b) Seismic vulnerability during construction (earthquake-prone zone)

◯ Very unlikely(1) ◯ Unlikely(2) ◯ Moderate(3) ◯ Likely(4) ◯ Very likely(5)

c) Site layout & congestion (space constraints)

◯ Very unlikely(1) ◯ Unlikely(2) ◯ Moderate(3) ◯ Likely(4) ◯ Very likely(5)

d) Access, traffic & logistics (delivery routes, site entrances, public traffic interaction)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

e) Weather & climate impacts (monsoon, extreme heat/cold, high wind)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

f) Surrounding hazards & public interface (adjacent buildings, pedestrians, environmental impacts)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

g) Force majeure events (Landslide, floods etc.)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

h) Land management issues (ownership disputes, unclear boundaries)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

2. What is the probability of occurrence of the following HUMAN FACTORS during building construction activities at site?

a) Worker skill level (trained vs untrained, certification)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

b) Labour turnover & reliance on temporary workforce

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

c) Language / communication barriers and supervision quality

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

d) Fatigue, working hours, and shift patterns

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

e) Unsafe acts (working at height, lifting, shortcuts)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

f) Worker safety awareness and individual reporting behavior

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

3. What is the probability of occurrence of the following SITE LEVEL PROJECT MANAGEMENT AND CONSTRUCTION EXECUTION FACTORS during building construction activities at site?

a) Contractor / site management competence

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

b) Subcontractor coordination

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

c) Planning and scheduling effectiveness

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

d) Site level decision-making and variation/change control

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

e) Pandemic and health emergency management (Covid 19, site shutdown)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

4. What is the probability of occurrence of the following TECHNICAL AND EQUIPMENT FACTORS during building construction activities at site?

a) Equipment condition, maintenance & inspection

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

b) Heavy machinery operations & operator competence

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

c) Scaffolding/ formwork and temporary works stability

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

d) Lifting operations & crane interface hazards

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

e) Struck-by-Object Hazards (falling materials/poor stacking)

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

f) Fire and Explosion hazards (hot works, short circuits, fuel storage, welding)

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

g) Electrical safety & temporary power arrangements

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

5. What is the probability of occurrence of the following MATERIAL AND PROCUREMENT FACTORS during building construction activities at site?

a) Material quality control & compliance with specifications

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

b) Material handling & storage practices

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

c) Supply chain reliability (timely delivery, vendor risk)

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

d) Theft / vandalism / security of stored materials

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

e) Material damage and wastages

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

6. What is the probability of occurrence of the following DESIGN, DOCUMENTATION AND COORDINATION FACTORS during building construction activities at site?

a) Incomplete or unclear drawings / specification

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

b) Design errors and omissions

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

c) Late design changes

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

d) Inadequate design provision for safe construction (edge protection, access)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

e) Constructability issue (Impractical construction methods)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

f) Interdisciplinary coordination (Example: MEP vs structural)

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

7. What is the probability of occurrence of the following SAFETY MANAGEMENT AND PROCEDURAL FACTORS during building construction activities at site?

a) Safety leadership and commitment

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

b) Frequency & quality of safety inspections / audits

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

c) Availability & correct use of PPE

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

d) Emergency preparedness and evacuation plans

Very unlikely(1) Unlikely(2) Moderate(3) Likely(4) Very likely(5)

e) Formal Incident reporting systems and procedure

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

f) Safety Training programs and toolbox talks

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

8. What is the probability of occurrence of the following REGULATORY AND COMPLIANCE FACTORS during building construction activities at site?

---

a) Permit and approval delays

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

b) Compliance with building codes

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

c) Enforcement of safety regulations

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

d) Record-keeping, authority inspections & documentation

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

e) Environmental regulations (waste disposal, noise, dust control)

Very unlikely(1) | Unlikely(2) | Moderate(3) | Likely(4) | Very likely(5)

Risk Consequence/Severity (level of impact)

1. What is the level of impact of the following SITE CONDITIONS AND ENVIRONMENT FACTORS during building construction activities at site?

---

a) Geotechnical / ground and soil conditions (poor site investigation, groundwater, slope stability)

Very Low(1) | Low(2) | Medium(3) | High(4) | Very High(5)

b) Seismic vulnerability during construction (earthquake-prone zone)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

c) Site layout & congestion (space constraints)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

d) Access, traffic & logistics (delivery routes, site entrances, public traffic interaction)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

e) Weather & climate impacts (monsoon, extreme heat/cold, high wind)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

f) Surrounding hazards & public interface (adjacent buildings, pedestrians, environmental impacts)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

g) Force majeure events (Landslide, floods etc.)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

h) Land management issues (ownership disputes, unclear boundaries)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

2. What is the level of impact of the following HUMAN FACTORS during building construction activities at site?

a) Worker skill level (trained vs untrained, certification)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

b) Labour turnover & reliance on temporary workforce

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

c) Language / communication barriers and supervision quality

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

d) Fatigue, working hours, and shift patterns

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

e) Unsafe acts (working at height, lifting, shortcuts)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

f) Worker safety awareness and individual reporting behavior

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

3. What is the level of impact of the following SITE LEVEL PROJECT MANAGEMENT AND CONSTRUCTION EXECUTION FACTORS during building construction activities at site?

a) Contractor / site management competence

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

b) Subcontractor coordination

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

c) Planning and scheduling effectiveness

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

d) Site level decision-making and variation/change control

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

e) Pandemic and health emergency management (Covid 19, site shutdown)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

4. What is the level of impact of the following TECHNICAL AND EQUIPMENT FACTORS during building construction activities at site?

a) Equipment condition, maintenance & inspection

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

b) Heavy machinery operations & operator competence

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

c) Scaffolding/ formwork and temporary works stability

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

d) Lifting operations & crane interface hazards

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

e) Struck-by-Object Hazards (falling materials/poor stacking)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

f) Fire and Explosion hazards (hot works, short circuits, fuel storage, welding)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

g) Electrical safety & temporary power arrangements

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

5. What is the level of impact of the following MATERIAL AND PROCUREMENT FACTORS during building construction activities at site?

a) Material quality control & compliance with specifications

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

b) Material handling & storage practices

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

c) Supply chain reliability (timely delivery, vendor risk)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

d) Theft / vandalism / security of stored materials

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

e) Material damage and wastages

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

6. What is the level of impact of the following DESIGN, DOCUMENTATION AND COORDINATION FACTORS during building construction activities at site?

a) Incomplete or unclear drawings / specification

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

b) Design errors and omissions

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

c) Late design changes

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

d) Inadequate design provision for safe construction (edge protection, access)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

e) Constructability issue (Impractical construction methods)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

f) Interdisciplinary coordination (Example: MEP vs structural)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

7. What is the level of impact of the following SAFETY MANAGEMENT AND PROCEDURAL FACTORS during building construction activities at site?

a) Safety leadership and commitment

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

b) Frequency & quality of safety inspections / audits

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

c) Availability & correct use of PPE

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

d) Emergency preparedness and evacuation plans

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

e) Formal Incident reporting systems and procedure

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

f) Safety Training programs and toolbox talks

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

8. What is the level of impact of the following REGULATORY AND COMPLIANCE FACTORS during building construction activities at site?

a) Permit and approval delays

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

b) Compliance with building codes

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

c) Enforcement of safety regulations

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

d) Record-keeping, authority inspections & documentation

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

e) Environmental regulations (waste disposal, noise, dust control)

Very Low(1) Low(2) Medium(3) High(4) Very High(5)

Risk Detectability

1. How easy/difficult is it to detect or identify the following SITE CONDITIONS AND ENVIRONMENT FACTORS during building construction activities at the site?

a) Geotechnical / ground and soil conditions (poor site investigation, groundwater, slope stability)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

b) Seismic vulnerability during construction (earthquake-prone zone)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

c) Site layout & congestion (space constraints)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

d) Access, traffic & logistics (delivery routes, site entrances, public traffic interaction)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

e) Weather & climate impacts (monsoon, extreme heat/cold, high wind)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

f) Surrounding hazards & public interface (adjacent buildings, pedestrians, environmental impacts)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

g) Force majeure events (Landslide, floods etc.)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

h) Land management issues (ownership disputes, unclear boundaries)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

2. How easy/difficult is it to detect or identify the following HUMAN FACTORS during building construction activities at the site?

a) Worker skill level (trained vs untrained, certification)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

b) Labour turnover & reliance on temporary workforce

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

c) Language / communication barriers and supervision quality

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

d) Fatigue, working hours, and shift patterns

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

e) Unsafe acts (working at height, lifting, shortcuts)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

f) Worker safety awareness and individual reporting behavior

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

3. How easy/difficult is it to detect or identify the following SITE LEVEL PROJECT MANAGEMENT AND CONSTRUCTION EXECUTION FACTORS during building construction activities at the site?

a) Contractor / site management competence

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

b) Subcontractor coordination

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

c) Planning and scheduling effectiveness

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

d) Site level decision-making and variation/change control

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

e) Pandemic and health emergency management (Covid 19, site shutdown)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

4. How easy/difficult is it to detect or identify the following TECHNICAL AND EQUIPMENT FACTORS during building construction activities at the site?

a) Equipment condition, maintenance & inspection

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

b) Heavy machinery operations & operator competence

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

c) Scaffolding/ formwork and temporary works stability

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

d) Lifting operations & crane interface hazards

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

e) Struck-by-Object Hazards (falling materials/poor stacking)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

f) Fire and Explosion hazards (hot works, short circuits, fuel storage, welding)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

g) Electrical safety & temporary power arrangements

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

5. How easy/difficult is it to detect or identify the following MATERIAL AND PROCUREMENT EQUIPMENT FACTORS during building construction activities at the site?

a) Material quality control & compliance with specifications

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

b) Material handling & storage practices

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

c) Supply chain reliability (timely delivery, vendor risk)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

d) Theft / vandalism / security of stored materials

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

e) Material damage and wastages

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

6. How easy/difficult is it to detect or identify the following DESIGN, DOCUMENTATION AND COORDINATION FACTORS during building construction activities at the site?

a) Incomplete or unclear drawings / specification

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

b) Design errors and omissions

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

c) Late design changes

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

d) Inadequate design provision for safe construction (edge protection, access)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

e) Constructability issue (Impractical construction methods)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

f) Interdisciplinary coordination (Example: MEP vs structural)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

7. How easy/difficult is it to detect or identify the following SAFETY MANAGEMENT AND PROCEDURAL FACTORS during building construction activities at the site?

a) Safety leadership and commitment

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

b) Frequency & quality of safety inspections / audits

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

c) Availability & correct use of PPE

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

d) Emergency preparedness and evacuation plans

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

e) Formal Incident reporting systems and procedure

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

f) Safety Training programs and toolbox talks

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

8. How easy/difficult is it to detect or identify the following REGULATORY AND COMPLIANCE FACTORS during building construction activities at the site?

a) Permit and approval delays

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

b) Compliance with building codes

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

c) Enforcement of safety regulations

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

d) Record-keeping, authority inspections & documentation

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

e) Environmental regulations (waste disposal, noise, dust control)

Very easy (1) | Easy (2) | Moderately (3) | Difficult (4) | Very Difficult (5)

Out of these 8 Factors which factor do you consider the most important factors during the building construction activities at the site?

Choose one or two only

- [ ] Site Conditions and Environment Factors
- [ ] Human Factors
- [ ] Site level Project management and Construction Execution Factors
- [ ] Technical and Equipment Factors
- [ ] Material and Procurement Factors
- [ ] Design, Documentation and Coordination Factors
- [ ] Safety Management and Procedural Factors
- [ ] Regulatory and Compliance Factors

APPENDIX B: QUESTIONNAIRE FOR CASE STUDY

Case study to evaluate site risk index during the public building construction

This scoring sheet is prepared for the field assessment of site risk index in building construction. The information obtained from this assessment will be solely for academic research purpose only. The thesis title is "Development of a Construction Site Risk Index (CSRI) Using Failure Mode and Effects Analysis (FMEA) for Public Buildings in Kathmandu Valley". This is an academic research done in partial fulfillment of the requirements for the degree of Master of Science in Construction Management at Institute of Engineering, Pulchowk Campus, Lalitpur.

Position of Participant:
Building Name:
Address:

Evaluation score	0	1
Pandemic and health emergency management (Covid 19, site shutdown)	No	Yes
Availability & correct use of PPE	Yes	No
Emergency preparedness and evacuation plans	Yes	No
Formal Incident reporting systems and procedure	Yes	No

Evaluation score	0	0.5	1
Contractor / site management competence	Good	Moderate	Poor
Subcontractor coordination	Good	Moderate	Poor
Planning and scheduling effectiveness	Good	Moderate	Poor
Site level decision-making and variation/change control	Good	Moderate	Poor
Compliance with building codes (RCF2)	Fully	Moderate	Never
Record-keeping, authority inspections & documentation (RCF4)	Always	Sometimes	Never

Evaluation score	0	0.25	0.5	0.75	1
Geotechnical / ground and soil conditions (poor site investigation, groundwater, slope stability) (SEF1)	Stable Condition	Slightly	Moderate	High	Failure
Seismic vulnerability during construction (earthquake-prone zone) (SEF2)	Negligible Vulnerabili ty	Minor	Moderate	High	Extreme
Site layout & congestion (space constraints) (SEF3)	Negligible Constraints	Slightly	Moderate	High	Extreme
Access, traffic & logistics (delivery routes, site entrances, public traffic interaction) (SEF4)	Negligible Issue	Minor	Moderate	High	Extreme
Weather & climate impacts (monsoon, extreme heat/cold, high wind) (SEF5)	No impact	Slightly	Moderate	High	Extreme
Surrounding hazards & public interface (adjacent buildings, pedestrians, environmental impacts) (SEF6)	No hazards	Minor	Moderate	High	Extreme
Force majeure events (Landslide, floods etc.) (SEF7)	No Exposure	Low	Moderate	High	Extreme
Land management issues (ownership disputes, unclear boundaries) (SEF8)	No disputes	Minor	moderate	High	Extreme
Worker skill level (trained vs untrained, certification) (HF1)	Very Highly	High	Moderate	Low	Very Low
Labour turnover & reliance on temporary workforce (HF2)	No turnover	Low	Moderate	High	Extreme
Language / communication barriers and supervision quality (HF3)	Clear	Minor	Moderate	Poor	Major
Fatigue, working hours, and shift patterns (HF4)	Well managed	Slightly	Moderate fatigue	High	Extreme

Unsafe acts (working at height, lifting, shortcuts) (HF5)	No	Rare	Occasion al	Frequen t	Very frequent
Worker safety awareness and individual reporting behavior (HF6)	Very Aware	Good	Moderate	Low	No
Equipment condition, maintenance & inspection (TEF1)	Excellent	Minor wear	moderate	Poor	Failure prone
Heavy machinery operations & operator competence (TEF2)	Highly Skilled	Good	Moderate	Poor	Untraine d
Scaffolding/ formwork and temporary works stability (TEF3)	Fully Stable	Minor	Moderate risk	Unsafe	Failure
Lifting operations & crane interface hazards (TEF4)	Fully controlled	Minor Risk	Moderate	High	Extreme
Struck-by-Object Hazards (falling materials/poor stacking) (TEF5)	No hazard	Rare	Occasion al	Frequen t	Very Frequent
Fire and Explosion hazards (hot works, short circuits, fuel storage, welding) (TEF6)	Fully Controlled	Minor	Moderate risk	High	Critical
Electrical safety & temporary power arrangements (TEF7)	Fully Safe	Minor issue	Moderate risk	Unsafe	Highly risk
Material quality control & compliance with specifications (MPF1)	Fully compliant	Minor defects	Moderate	Poor quality	Unaccept able
Material handling & storage practices (MPF2)	Proper	Minor issue	Moderate	Unsafe	Highly Unsafe
Supply chain reliability (timely delivery, vendor risk) (MPF3)	Fully reliable	Minor delay	Moderate	Frequen t	Unrelaibl e
Theft / vandalism / security of stored materials (MPF4)	Fully secure	Minor risk	moderate	High	Severe Losses
Material damage and wastages (MPF5)	No	Minor	Moderate	High	Severe

Incomplete or unclear drawings / specification (DDCF1)	Very Clear	Minor unclear	Moderate	High unclear	Very High
Design errors and omissions (DDCF2)	No errors	Minor errors	Moderate	High	Major errors
Late design changes (DDCF3)	No change	Minor change	Moderate	Frequent	Continious
Inadequate design provision for safe construction (edge protection, access) (DDCF4)	Fully incorporate	Minor gaps	Moderate	Poor	No safe
Constructability issue (Impractical construction methods) (DDCF5)	Very practical	Minor difficulty	Moderate	Difficult	Impractical
Interdisciplinary coordination (Example: MEP vs structural) (DDCF6)	Fully coordinated	Minor conflicts	Moderate	Major	Severe clashes
Safety leadership and commitment (SPF1)	Very Strong	Good	Moderate	Weak	No leadership
Frequency & quality of safety inspections / audits (SPF2)	Always Conducted	Regular	Occasional	Rare	Never
Safety Training programs and toolbox talks (SPF6)	Frequent	Regular	Occasional	Rare	Never
Permit and approval delays (RCF1)	No delay	Minor delay	Moderate	Significant	Always
Enforcement of safety regulations (RCF3)	Strong enforcement	Good	Moderate	Weak	No enforcement
Environmental regulations (waste disposal, noise, dust control) (RCF5)	Fully compliant	Minor issue	Moderate	Major	Severe non compliance

APPENDIX C: CASE STUDY SITE PHOTOGRAPHS

Project A (Sathi Women's Shelter, Bagdol, Lalitpur)

Project B (Integrated Hulak Office Building, Babarmahal, Kathmandu)

ANNEX I: ACCEPTANCE LETTER FOR 18TH IOE GRADUATE CONFERENCE

[IOEGC18] Editor Decision Inbox ×

Dr. Pradeep Shrestha <ioegc17@gmail.com> Sun 26 Apr, 22:30 (6 days ago)

to me

anish karki:

We have reached a decision regarding your submission to 18th IOE Graduate Conference, "Development of a Construction Site Risk Index (CSRI) Using Failure Mode and Effects Analysis (FMEA) for Public Buildings in Kathmandu Valley, Nepal".

Our decision is to: Accept Submission

With Warm Regards,
IOEGC-18 Editorial Team

ANNEX II: ORIGINALITY REPORT

iThenticate

Similarity Report ID: oid:3117:584569087

PAPER NAME

Development and Application of a Construction Site Risk Index Model Using FMEA for Public Building Projects in Kathmandu Valley, Nepal

AUTHOR

ANISH KARKI

WORD COUNT

15473 Words

CHARACTER COUNT

87599 Characters

PAGE COUNT

77 Pages

FILE SIZE

802.4KB

SUBMISSION DATE

Apr 29, 2026 10:22 PM GMT+5:45

REPORT DATE

Apr 29, 2026 10:22 PM GMT+5:45

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