Power System Protection and Control
ISSN:1674-3415

ANALYSIS OF FACTORS AFFECTING RISK MANAGEMENT FOR RESIDENTIAL BUILDING PROJECTS IN INDIA

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Received:15 February 2025 **Revised**:18 March 2025 **Accepted**: 8 April 2025

ABSTRACT:

Risk management plays a crucial role in ensuring the successful construction of residential building projects in India, where various uncertainties and challenges can affect project performance. This study investigates the external and internal factors influencing risk management in the residential construction projects. Through an extensive literature review and data collection by conducting a quantitative survey, this study identifies critical factors related to design and planning issues, site-related challenges, material management concerns, financial problems, labour-related problems, and equipment-related issues. Additionally, the study considers legal and contractual risks; health, safety & environmental concerns; technological uncertainties; market and economic fluctuations; communication and coordination barriers; public and social concerns; and challenges within the project management team. The one-way ANOVA and the Relative Importance Index (RII) are the methods implemented to find the statistical significance of the factors and rank those factors based on their impact level. The study provides insights into effective risk management practices specific to the Indian construction sector, aiding construction professionals in developing proactive risk mitigation frameworks that enhance project efficiency, minimise uncertainties, and optimise overall project outcomes.

Keywords*: Risk Management, Factors Affecting, Residential Building, One-Way Anova, Relative Importance Index (Rii) Method.*

1. INTRODUCTION

Risk management is an important aspect in residential building projects because there are several stakeholders, complex procedures, and various uncertainties involved. Appropriate risk management procedures ensure timely completion of the project, strict adherence to budget limits, and compliance with quality standards. The procedure involves systematic identification, assessment, mitigation, and monitoring of risks that could affect the project's success. Because the construction environment continues to change, effective risk management eliminates probable interference and enhances the project's overall efficiency. Residential construction projects face an array of risks, ranging from financial, operational, legal, environmental, and safety-related risks. Financial risks, such as cost overruns, price volatility of materials, and funding shortages, can significantly impact the viability of a project. Operational risks, such as inefficient allocation of resources and poor site management, can potentially result in delays and inefficiencies. In addition, compliance with legal and regulatory requirements is also important; the failure to comply with building codes and safety regulations can lead to fines or legal challenges. Environmental risks, such as extreme weather conditions and natural disasters, can also negatively impact project timelines.

The construction industry is inherently complex, with diverse stakeholders involved, which makes it susceptible to a wide array of risks. Poor risk management measures can cause project delays, cost overruns, and quality issues, ultimately threatening the success of projects [1]. Construction projects are exposed to risks from design flaws, logistical issues, financial constraints, and environmental factors, all of which introduce uncertainties that can hinder project completion [2]. Given the prolonged duration and complex nature of these projects, setting up a strong risk management framework is extremely crucial. It involves the identification, evaluation, planning, and monitoring of risks to prevent possible disruptions and ensure smooth execution [3]. Common risks in the residential construction sector involve lack of planning, unsafe working environments, substandard material, and ineffective resource allocation. Mitigation of these problems through proactive risk management measures improves overall project effectiveness and reduces the likelihood of failures [4]. Further, some geographic locations face unique challenges that require specialised risk management strategies. For instance, construction projects in the Gaza Strip are affected by specific political, logistical, and economic challenges. Proper containment of these localised risks and developing tailored strategies can enhance project outcomes despite the issues prevailing in the region [10].

1.1 Research Problem and Hypothesis

The goal of this study is to find out the top 10 most significant factors that affecting on risk management in residential construction projects. An in-depth literature review was first conducted, which filtered 43 significant factors that are industry-tested by professionals such as project managers, engineers, and contractors. Data are collected using a questionnaire survey, which yielded 107 valid responses out of 159 received responses. Data were then computed using a one-way ANOVA test to identify the statistical significance of the factors, followed by the Relative Importance Index (RII) method to identify the top 10 most significant factors based on the degree of their impact on risk management. These factors create various uncertainties in residential construction projects, which result in project delays.

2. LITERATURE REVIEW

The study emphasises the importance of identifying and ranking critical risk factors while proposing a risk mitigation model. It adopts a systematic approach to risk management by categorising risk factors and utilising techniques such as the Relative Importance Index (RII) for analysis. The study specifically focuses on key risk categories, including resource-related, site-related, management, and sociopolitical risks. By addressing these risks throughout the project lifecycle, it aims to minimise negative impacts and enhance positive outcomes, ensuring better project performance and sustainability. [1]

A systematic risk management strategy is required to address 47 risk factors that are encountered in the project life cycle. It is initiated with risk identification, classifying hazards into design, logistics, legal, environmental, financial, and other broad categories. Risk assessment is conducted using qualitative tools such as risk matrices and quantitative tools such as Monte Carlo simulations. Risk reduction and response planning involves measures to avoid, reduce, transfer, or accept risks, with proper control measures established. Such a systematic approach improves project resilience and ensures effective project execution. [2]

The study investigates the field of risk management of high-rise building constructions in the context of Indian urban development. Examines different strategies with risk assessment and safety management, highlighting their importance in the avoidance of delays, unnecessary expenses, and safety concerns. The paper describes a comprehensive risk management process through phases of identification, evaluation, action, and monitoring. For the purpose of facilitating scheduling and performing risk analysis, computer tools such as Microsoft Project (MSP) and Risky Project Professional (RPP) are utilised. It identifies significant risks associated with high-rise construction, which are technical, financial, physical, and construction-related risks. It also highlights the incorporation of risk management practices into project schedules to prevent probable delays and expenses, thus defining its central role to facilitate the successful completion of construction projects. [3]

Integrating the Analytical Hierarchy Process (AHP) with fuzzy risk analysis offers construction contractors a structured framework to evaluate and prioritise projects during tendering. This approach assesses various risk factors, such as market conditions and potential time delays, to minimise financial losses and resource misallocation. For instance, in a study of HVAC projects in Egypt and Saudi Arabia, this combined methodology identified a Saudi Arabian project as the most viable option due to its favourable financial and market conditions. This integrated model aids contractors in mitigating risks and optimising project selection decisions. [4]

The study investigates the impact of external factors on construction risk management (CRM) in Nigerian enterprises. The findings reveal that technology advancements, including new materials and methods, significantly affect CRM practice. Economic factors, including inflation and exchange rates, also play a significant role in effective risk management. Surprisingly, political instability and government policies have minimal effects on CRM. The study employs Partial Least Squares-Structural Equation Modelling (PLS-SEM) and gathers responses from 238 participants, demonstrating the highest significance of technology and economic stability in risk management in the construction sector. [5]

The research explores the key factors for effective risk management at the execution stage of construction projects. Risk management, mainly at the planning stage, is discussed in the majority of literature, and this paper stresses the importance of dealing with risks as they occur at the execution stage. Drawing from surveys and interviews of practitioners in the industry, the research identifies four general categories of key success factors: organisational, human behavioural, procedural, and external. Project management skills, experience, early contractor involvement, and socio-cultural issues are specifically highlighted under these categories. The research reiterates the importance of active risk management and thus enables better decision-making and project success. [6]

A Case Study in Design-Build Projects in Vietnam discusses risks and challenges of design-build (DB) projects in Vietnam's construction sector. It emphasises the change from the conventional design-bid-build (DBB) system to DB contracts, which are designed to simplify the delivery of projects, cut costs, and enhance efficiency. The study identifies the main risk factors, such as political. [7]

This paper discusses the most critical risks affecting construction projects in developing nations. The study is based on an extensive literature review, which assesses available research into risk management in the construction industry. The authors cite 111 different risk factors, of which 56 of them are the most critical, affecting cost, duration, and quality. The significant risks that have been identified include inflation, labour productivity, political instability, and regulations. This study provides findings that are critical to project managers in designing better risk mitigation measures. [8]

The study examines the major causes of project delays in India using surveys and statistical methods like factor analysis and regression modelling. It identifies key delay factors such as lack of commitment, ineffective site management, poor coordination, unsuitable planning, and poor-quality contracts. The regression model highlights significant contributors, including slow decision-making by owners, poor labour productivity, architects' resistance to change, and rework due to execution errors. Emphasising the need for a systematic project management plan, the study aims to mitigate delays and enhance industry efficiency. [9]

The study examines risk factors affecting construction projects in the Gaza Strip, a region with political and economic challenges. A questionnaire survey among industry professionals identifies key risks in political, logistical, management, legal, physical, technical, and design-related categories. Political risks, such as border closures, security instability, and restricted material access, are the most critical, disrupting project timelines and costs. Logistical risks, including material price fluctuations and financial instability, also pose challenges. The study needs effective risk management and specialised professionals for security, safety, and planning. Improved management and policy interventions can enhance project efficiency and success. [10]

This study examines residential construction project risks in India's construction industry, emphasising the need for efficient risk management due to project uncertainties. Using fuzzy set theory, the authors propose a framework to handle imprecise risk assessment data. A survey of 52 risk factors was analysed with MATLAB's fuzzy logic toolbox, revealing that resource, architect, and project management risks require careful planning. The fuzzy method quantifies risk severity, aiding decision-making to reduce delays, cost overruns, and conflicts in construction projects. [11]

This paper examines key factors influencing project performance in the Indian construction industry. The study highlights that the construction sector in India faces multiple challenges, including cost overruns, delays, and fragmented management practices. Using a survey-based methodology, the author identified 28 performance areas that impact project success. Through factor analysis and multiple regression analysis, they grouped these into nine significant categories, such as quality, schedule, cost, productivity, safety, communication management, and customer relations. The study found that "customer relations" and "schedule" are the most influential factors affecting project performance. The findings provide valuable insights for construction professionals to enhance efficiency and prioritise critical areas for project success. [12]

A study explores the drivers of success for construction projects within the Architecture, Engineering, and Construction (AEC) sector. It discusses the impacts of the industry's inherently fragmented character and other

DOI: 10.46121/pspc.53.2.3

difficulties, including scheduling delays, over-budgeting, shortages of labour, and poor planning, on project efficiency. The study utilises primary data from the Indian construction sector gathered from the administration of structured questionnaires, which were factor analysed. The findings specify five determinants of project performance: site management and coordination, leadership and finance management, planning, commitment, and communication. This study highlights the necessity for enhancing management practices, planning strategy, and coordination mechanisms to ensure project success for the construction industry. [13]

A study analyses determinants of Pune, India, residential apartment rental prices. Utilising sophisticated econometric regression techniques, the study finds structural determinants like overall floor area and number of rooms to have a positive impact on rental prices. In addition, proximity to emergency services, workplaces, schools, and public transportation stations has a significant impact on rental prices because the residents want efficiency and security. Interestingly, apartments at longer distances from central business districts (CBDs) and hospitals have higher rental prices, likely due to having lower congestion and pollution levels. The study strongly suggests the importance of income group-specific public rental home policies in order to appropriately address the growing trends of urban migration. [14]

The study analyses data from 102 residential building construction projects completed during 2013-2018, and it concludes that all projects had cost overruns averaging an escalation of 34.58%. The manuscript lists prominent causes of such cost overruns as a shortage of contractual experience, insufficient time given to cost estimation, lack of complete architectural plans, volatile prices of materials, and political turmoil. Regression analysis indicates an association between large contract values and large cost overruns. The study also encompasses a survey of consultants and contractors and their conclusions concerning the causes of cost overruns. The conclusions make recommendations for improving cost management in building construction, emphasising the need for increased planning and increased financial management. [15]

3. METHODOLOGY

Research Design

The methodology utilised in this study adopts a systematic approach that assessed the critical determinants that affect the risk management in residential construction projects. The study begins with a careful analysis of literature, where related studies, theoretical models, and published articles are explored to create an effective understanding of the factors and the risk management approaches. The 43 factors are identified from the construction experts. Apart from this, the questionnaire is created and distributed to the concerned stakeholders to identify the impact of different factors on the risk management. Moreover, a one-way ANOVA test is employed, which is a statistical technique applied for data analysis and interpretation of trends, association, and statistical significance among the identified risk factors. The Relative Importance Index (RII) approach is applied finally to identify the most impacting factors affecting risk management and prioritise them based on the impact level. The purpose of this study is to identify the key critical factors affecting risk management in residential construction projects that lead to delays in the completion of the project.

Data Collection

The data collection strategy is essential to determine the crucial factors. Firstly, the extensive literature review is carried out, and 60 factors affecting risk management are identified. To achieve the factors that are more unique and specific to residential buildings, the discussions arranged with the construction professionals resulted in 43 unique factors being obtained, as shown in Table 1. The questionnaire is created and distributed to 159 construction industry experts, out of whom 107 valid responses were received, thus achieving the desired sample size. There are three categories from whom the data is collected, such as project managers, contractors, and engineers, as shown in Fig. 1. This data collection is essential in reducing the uncertainties and challenges surrounding residential construction projects.

Table 1 Factors Affecting Risk Management in Residential Projects

Factor ID	Factors name
F1	Lack of consistency between bill of quantities, drawings, and specifications
F2	Supplier frequently delivers defective materials

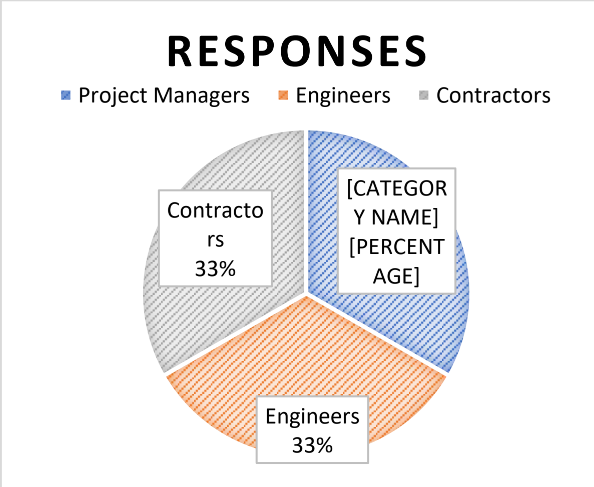
DOI: 10.46121/pspc.53.2.3

F3	Labour, materials, and equipment's are often unavailable on-site
F4	Environmental factors (floods, earthquakes, etc.)
F5	Poor communication between clients, consultants, contractors, and stakeholders
F6	Unmanaged cash flow (poor cash flow management)
F7	Design errors or changes
F8	High financing costs
F9	Price fluctuations in labour/material/equipment (L/M/E)
F10	Changes in labour safety laws and regulations
F11	Poor Adverse site or ground conditions
F12	Delay in payment / Payment issues
F13	Shortage or delay in delivery of expected materials on-site
F14	Non availability of drawing/design on time
F15	Lack of skilled operators required for specialized equipment
F16	Shortage of construction materials in the market
F17	Unstable market conditions (supply and demand, competition)
F18	Public opposition to the project
F19	Use of improper, poor complex construction methods/techniques
F20	Changes in technology during the project
F21	Construction cost overruns
F22	Improper investigation of geotechnical and underground conditions
F23	Poor project management skills of the project team
F24	Improper project planning, budgeting and schedule issues
F25	Poor site management and supervision
F26	Changes in government laws, regulations, and policies
F27	High degree of construction risk
F28	Delay in solving dispute problems
F29	Higher maintenance costs than expected
F30	Faulty workmanship during construction
F31	Use of new material and components in buildings
F32	Uncertainty of taxes affecting the project
F33	Increase in project durations during construction
F34	Delay in obtaining permits and licenses
F35	Improper project feasibility study
F36	Poor workmanship during construction/maintenance
F37	Damage to property due to unsafe operations

DOI: 10.46121/pspc.53.2.3

F38	Faulty soil investigation report issue
F39	Improper storage of materials leading to damage
F40	Lack of protection on a construction site
F41	Not coordinated design (structural, mechanical, electrical, etc.)
F42	Project-funding problems
F43	Occurrence of Site accidents because of poor safety procedures

Fig 1 Category of Involved Experts in Survey



Data Analysis
In the data analysis section, the gathered data is examined using a one-way ANOVA test to assess differences between groups of independent variables and determine whether the identified factors are statistically significant. Additionally, the Relative Importance Index (RII) is utilised as a statistical technique to calculate and categorise the 43 factors on the basis of their impact or significance on the risk management. This approach enabled a structured prioritisation of the most critical factors, highlighting their influence on the risk management in residential construction projects.

4. RESULT

The results section provides an elaborate discussion of factors influencing risk management for residential construction projects; a total of 43 impactful factors were derived from construction experts. A questionnaire survey was prepared and distributed to 159 industry professionals, and 107 valid responses were obtained. A one-way ANOVA analysis is applied to identify the most statistically significant risk factors, and the Relative Importance Index (RII) method is utilised to assess the most important risk factors based on their respective influence levels. It was found that the top 10 important factors have a critical influence on risk management for residential projects. These important factors can be monitored collectively to avoid delays, reduce cost overruns, and rectify safety issues, thus ensuring the formulation of effective risk management strategies to promote the efficiency and success of residential construction projects.

Relative Importance Index (RII)
The data from completed surveys have been utilised for the final analysis; the survey was submitted to 159 construction industry experts, out of which 107 valid responses were derived. Hence, 107 numbers of feedback have been applied for the final data analysis. A questionnaire was designed using a five-point Likert scale between 1 and 5 rating.

Identify critical risk factors influencing risk management and assign ranks based on their importance or impact level using the Relative Importance Index (RII) formula. [16]

Relative Importance Index (RII) = ∑W / (A*N)
Where the symbol represents,

- W = the weight assigned by the respondents to each factor on a 1 to 5 scale with 1 = strongly disagree, 2 = disagree, 3 = neutrality, 4 = agree, and 5 = strongly agree.
- A = Highest weight (in this study, it is 5)
- N = Total number of respondents

Applying the Relative Importance Index (RII) technique, the output of various factors is presented in Table 2. It contains a survey data analysis of 43 distinct factors, from their factor ID, RII value, and corresponding rank. The factors are presented in hierarchical order based on their influence levels, in descending order.

Table 2 Ranking of Factors Affecting in Residential Projects

Factors ID	RII	Rank
F9	0.870440252	1
F20	0.86918239	2
F32	0.866666667	3
F35	0.856603774	4
F22	0.849056604	5
F26	0.847798742	6
F36	0.846540881	7
F38	0.841509434	8
F3	0.840251572	9
F16	0.838993711	10
F21	0.837735849	11
F18	0.835220126	12
F25	0.835220126	13
F39	0.835220126	14
F43	0.831446541	15
F4	0.828930818	16
F41	0.828930818	17
F37	0.827672956	18
F19	0.826415094	19
F24	0.825157233	20
F10	0.812578616	21
F12	0.812578616	22
F33	0.811320755	23
F14	0.806289308	24
F17	0.806289308	25
F30	0.798742138	26
F11	0.797484277	27
F27	0.796226415	28
F40	0.793710692	29
F31	0.788679245	30
F29	0.78490566	31
F5	0.779874214	32
F1	0.766037736	33
F23	0.764779874	34
F7	0.752201258	35
F28	0.743396226	36
F42	0.739622642	37
F8	0.735849057	38
F6	0.716981132	39
F34	0.716981132	40
F2	0.710691824	41
F13	0.68427673	42
F15	0.670440252	43

Power System Protection and Control
ISSN:1674-3415

The “Factor ID” column contains the distinct identification number for every factor, while the “RII value” column shows the relative importance value given for each factor. A maximum RII value shows a higher potential influence on construction projects, while a smaller value shows a minimum influence.

One-way ANOVA Analysis

In empirical research with multiple independent variables, one-way analysis of variance (ANOVA) is a strong statistical technique for testing group mean differences and determining the presence of statistically significant differences in responses across various groups regarding all factors. Such a technique tests the effect of more than one independent variable on one dependent variable (risk management) by measuring variability between and within groups. This study tests 43 factors affecting risk management in residential construction projects. This analysis is done on data obtained from 107 valid responses. To calculate the statistical significance of identified factors, the one-way ANOVA test was utilised. A one-way ANOVA can be utilised to find any significant differences that may exist between the 43 factors affecting risk management in residential construction.

Table 3 Anova: Single Factor

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
F1	107	414	3.869159	0.548757
F2	107	413	3.859813	0.970728
F3	107	438	4.093458	1.104391
F4	107	445	4.158879	1.002821
F5	107	439	4.102804	0.753483
F6	107	436	4.074766	0.78681
F7	107	411	3.841121	1.021689
F8	107	439	4.102804	0.885558
F9	107	430	4.018692	0.943044
F10	107	433	4.046729	0.818551
F11	107	431	4.028037	0.819961
F12	107	461	4.308411	0.536061
F13	107	447	4.17757	0.807794
F14	107	449	4.196262	0.668665
F15	107	440	4.11215	1.043908
F16	107	403	3.766355	1.143008
F17	107	417	3.897196	0.904426
F18	107	425	3.971963	0.952037
F19	107	434	4.056075	0.940222
F20	107	440	4.11215	0.9307
F21	107	440	4.11215	0.968436
F22	107	434	4.056075	0.713807
F23	107	444	4.149533	0.713278
F24	107	437	4.084112	1.058896
F25	107	436	4.074766	0.69247
F26	107	431	4.028037	0.857697
F27	107	458	4.280374	0.63763
F28	107	438	4.093458	0.896844
F29	107	422	3.943925	0.713807
F30	107	419	3.915888	1.002292
F31	107	426	3.981308	0.867572
F32	107	440	4.11215	0.892964
F33	107	460	4.299065	0.645565
F34	107	435	4.065421	0.778699
F35	107	429	4.009346	1.009346
F36	107	447	4.17757	0.902134
F37	107	418	3.906542	1.085523
F38	107	416	3.88785	1.081643
F39	107	447	4.17757	0.921002

F40	107	438	4.093458	1.123259
F41	107	409	3.82243	0.675719
F42	107	440	4.11215	0.628813
F43	107	436	4.074766	0.654735

The above Table 3 shows the output of a one-way ANOVA test conducted on various groups, from factors ID F1 to F43. It gives a summary of significant statistical measures such as count, sum, average, and variance for every group. With 107 observations per category, the sample size is uniform across all groups. The average values display minimal variation, indicating consistency in group means, while the variance values differ, indicating variations in data distribution. The primary aim of this ANOVA test is to identify whether the variations in group means are statistically significant or resulted from random variation. By examining these statistical measures, the study aims to establish the presence of significant variations in the data.

Table 4 One-way Analysis

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	71.27364	42	1.696991	1.966612	0.000205	1.386655
Within Groups	3933.103	4558	0.862901			
Total	4004.376	4600				

The result represents a one-way ANOVA (Analysis of Variance) test, which is used to compare the means of multiple groups to determine whether there are significant differences among them. Table 4 includes key statistical components such as the sum of squares (SS), degrees of freedom (df), mean square (MS), F-statistic (F), p-value, and critical F-value (F crit).

The total variability is split into "Between Groups" and "Within Groups". The sum of squares (SS) for "Between Groups" is 71.27364, and for "Within Groups" it is 3933.103, so the total SS is 4004.376.

The degrees of freedom (df) for "Between Groups" is 42, and for "Within Groups" it is 4558, so the total is 4600. The mean square (MS) values are 1.696991 for "Between Groups" and 0.862901 for "Within Groups".

The F-statistic is 1.966612, whose corresponding p-value is 0.000205, which is much smaller than the standard significance level of 0.05.

Since the F-statistic (1.966612) is larger than the critical F-value (1.386655), we reject the null hypothesis; it establishes that there are statistically significant differences between the group means.

5. CONCLUSION

The study identifies and ranks 10 critical risk factors influencing risk management in residential construction projects as shown in Table 5. Statistical significance of the different factors was determined by performing a one-way ANOVA to ensure that only the most important risks are assessed. The Relative Importance Index (RII) approach was used to rank the top 10 critical risk factors by severity and impact on project outcomes. Mitigating these key risks can significantly minimise their adverse effects, resulting in improved project performance, reduced delays, and cost overruns. The improvement of these factors allows construction stakeholders to maximise project efficiency, reduce uncertainties, and improve the overall success of residential construction projects. This research offers useful insights for project managers, contractors, and policymakers to formulate effective risk management plans and make more informed decisions for future projects.

DOI: 10.46121/pspc.53.2.3

Table 5 Top 10 Most Critical Risk Factors Affecting Risk Management in Residential Projects

Factors ID	Top 10 Factors	RII	Rank
F9	Price fluctuations in labour/material/equipment (L/M/E)	0.870440252	1
F20	Changes in technology during the project	0.86918239	2
F32	Uncertainty of taxes affecting the project	0.866666667	3
F35	Improper project feasibility study	0.856603774	4
F22	Improper investigation of geotechnical and underground conditions	0.849056604	5
F26	Changes in government laws, regulations, and policies	0.847798742	6
F36	Poor workmanship during construction/maintenance	0.846540881	7
F38	Faulty soil investigation report issue	0.841509434	8
F3	Labour, materials, and equipment's are often unavailable on-site	0.840251572	9
F16	Shortage of construction materials in the market	0.838993711	10

The leading factor is “F9”, with the highest RII value of 0.8704, indicating that cost variations significantly impact project execution. The second-ranked factor was “F20” with an RII of 0.8691, indicating a significant impact on project timelines. Ranked third, “F32” with an RII of 0.8666, highlighting the financial unpredictability faced by construction stakeholders. The fourth position was held by “F35” (RII 0.8566), emphasising the importance of comprehensive planning before project execution. The “F22” ranked fifth with an RII of 0.8490, underlining the need for detailed site analysis. The sixth-ranked factor was “F26” scoring 0.8477, demonstrating the impact of legal frameworks on construction projects. The “F36” was seventh (RII 0.8465), reflecting the importance of skilled labour and quality control. At eighth place, “F38” (RII 0.8415) highlights the consequences of inaccurate geological assessments. The “F3” ranked ninth with an RII of 0.8402, pointing to logistical challenges affecting project timelines. Lastly, “F16” secured the tenth position (RII 0.8389), reinforcing the significance of supply chain management in construction. These findings underscore key risk areas that must be improved to ensure smoother project management, reduce potential disruptions, and make projects successful.

6. ACKNOWLEDGMENT

I am deeply grateful to Lord Shiva for granting me the strength, wisdom, and perseverance to complete this research. Without His blessings and guidance, this work would not have been possible. Special thanks to my guide, Prof. Darshit Shah, and co-guide, Prof. Jaydeep Pipaliya, for their invaluable guidance. I also express my gratitude to my friends for their support and to my father, Mr. Suresh, for his blessings.

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