CHAPTER 74

Identifying and Controlling Real Estate Projects Delays: A Pune Region Study with SPSS

Kolhe[1], Hemendra Wani[2], Raja Udandarao[2] and Harshit Gupta[2]

ABSTRACT

The real estate sector in India is a cornerstone of urban growth and economic progress. The conditions in the Pune real estate sector are expanding continuously. However, project delays have become a prevalent problem, causing financial losses and reducing stakeholder trust. These delays often stem from issues like inefficiencies in planning, communication breakdowns, and logistical hurdles, making it difficult to meet project timelines. To address these issues, this study adopts a systematic approach by collecting data through structured questionnaire surveys and interviews with key construction industry stakeholders, including contractors, engineers, and consultants. Advanced statistical analysis was employed to identify and prioritize the critical factors contributing to schedule delays. The findings of this research emphasize the need for adopting modern project management strategies that focus on improving planning accuracy, enhancing collaboration among stakeholders, and streamlining processes. These insights lay the groundwork for developing actionable recommendations to minimize delays and ensure timely project delivery in dynamic real estate sector.

Keywords: Real estate delays; Pune construction; Delay mitigation; SPSS.

1.0 Introduction

The real estate sector is a cornerstone of urban development and economic growth in India. Pune, being one of the fastest growing cities in the country, has witnessed a surge in real estate projects. However, delays in these projects have become a significant concern, leading to financial losses, legal disputes, and a decline in stakeholder confidence. Delays in construction projects can be attributed to various factors, including inadequate planning, poor site management, financial constraints, and regulatory hurdles. This study focuses on identifying the key factors causing delays in real estate projects in the Pune region and proposes mitigation strategies to control these delays. By analyzing the responses from industry stakeholders using advanced statistical tools like SPSS and the Relative Importance Index (RII), this research aims to provide actionable insights for improving project management practices and ensuring timely project completion.

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Extensive research has been conducted on construction delays globally and in India, but there is a lack of region-specific studies that quantitatively analyze Pune's real estate delays. While previous studies have identified delay factors qualitatively, few have ranked them using Relative Importance Index (RII) or analyzed interdependencies using Principal Component Analysis (PCA).

2.0 Literature Review

Construction delays in real estate projects are a global issue, leading to cost overruns, legal disputes, and inefficiencies. Various studies have analyzed the causes of delays and suggested mitigation strategies using methodologies like the Relative Importance Index (RII) and Principal Component Analysis (PCA) to identify critical factors. Delays are often classified into categories such as contractor-related issues, consultant inefficiencies, material shortages, labor challenges, external influences, and design errors (Edison & Singla, 2020). Additional contributing factors include delays in approvals, frequent design revisions, labor incompetence, unrealistic planning, and inadequate project monitoring (Kalkani & Malek, 2016). Financial constraints, particularly delayed payments and cash flow problems, significantly impact project timelines (Prasad & Vasugi, 2018; Ferreira, 2024).

Regulatory inefficiencies, such as slow land acquisition, approval delays, and contract mismanagement, further hinder progress (Nallatiga, 2017). Corruption in procurement and contract awards exacerbates delays (Le *et al.*, 2014). Changes in project scope and poor planning also contribute to schedule disruptions (Sampatha *et al.*, 2024). Modern construction technologies can mitigate delays, but slow adoption of tools like Building Information Modelling (BIM) and real-time tracking remains an issue (Tayal & Yadav, 2024). Studies using RII have identified financial constraints, poor contractor performance, and bureaucratic delays as critical factors (Nallatiga, 2017; Bhavsar *et al.*, 2024). PCA helps simplify complex datasets, grouping delay factors into key components for better analysis (Edison & Singla, 2020; Gupta & Vyas, 2024). Combining RII and PCA provides a robust approach to prioritizing delay factors and formulating mitigation strategies. Recommended solutions include improved financial management, streamlined approval processes, enhanced stakeholder coordination, and the adoption of Industry 4.0 technologies (Ferreira, 2024; Nallatiga, 2017; Tayal & Yadav, 2024; Arantes & Ferreira, 2020).

3.0 Research Methodology

This approach involves gathering insights from a variety of construction stakeholders—contractors, engineers, consultants, supervisors, draftsmen, and workers—using structured questionnaire surveys. By employing the Relative Importance Index (RII), we assess the severity of each delay cause identified, ranking them according to their impact. This allows

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stakeholders to concentrate their efforts on the most pressing issues. With this data, we can create specific recommendations to address these delays, encouraging proactive steps to enhance project management and minimize disruptions. This framework not only helps in understanding the complexities of real estate construction delays but also emphasizes the importance of using analytical methods like RII to improve project outcomes and reduce risks.

Figure 1: Process Flowchart

Questionnaire Survey: Data was collected through structured questionnaires, which were designed after a thorough review of existing literature. These questionnaires, featuring 20 questions on a Likert scale, targeted various stakeholders, including contractors, engineers, and clients, with the aim of pinpointing the factors behind project delays. This methodical approach ensured a comprehensive gathering of insights, crucial for identifying and addressing the root causes of delays in construction projects. The questionnaire was distributed among clients, contractors, and consultants to capture a broad spectrum of perspectives.

RII Calculation: The data was analyzed using SPSS to uncover patterns and calculate the Relative Importance Index (RII), which helped prioritize the causes of delays based on their significance as perceived by the respondents. This analysis facilitated a more targeted approach in addressing the most critical issues affecting project timelines.

Principle Component Analysis: Principal Component Analysis (PCA) was applied to simplify the data, grouping related delay factors and focusing on the major contributors to project delays. This statistical technique helped to reduce the complexity of the data set, making it easier to identify and address the most impactful issues.

Recommendations: From our findings, we suggest practical strategies to reduce delays, emphasizing better planning, enhanced communication among stakeholders, and efficient resource management to ensure projects stay on track.

4.0 Results and Discussion

4.1 RII results

The comprehensive analysis of Relative Importance Index (RII) values across various charts heatmap, bar chart, and radar chart provides a detailed perspective on the factors

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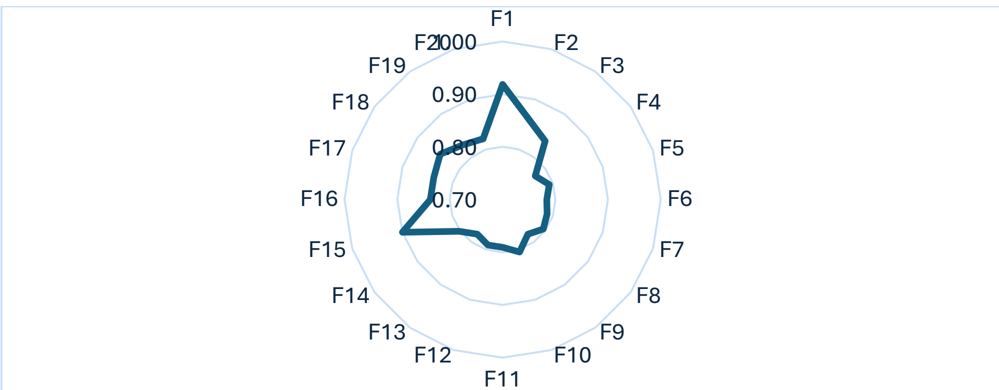
contributing to delays in real estate projects. These visual tools reinforce and clarify the impact of specific challenges, with inadequate project planning and scheduling (F1) consistently identified as the most critical factor. This is depicted through its top ranking across all charts with an RII value of 0.9186, strongly emphasizing the paramount importance of robust planning and effective scheduling in project management.

Figure 2: RII Heat Map

F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
0.92	0.86	0.84	0.78	0.79	0.78	0.79	0.80	0.78	0.80	0.79	0.79	0.78	0.80	0.90	0.84	0.84	0.85	0.83	0.82

Financial constraints faced by contractors, represented by F4, are another key factor highlighted in the analysis. With an RII of 0.7767, it underscores the critical need for financial management and stability to ensure that projects are not hindered by monetary issues. This comprehensive evaluation through different analytical charts not only points out the most pressing concerns but also serves as a guide for prioritizing interventions and resources to address these pivotal issues effectively, ultimately aiming to enhance project efficiency and reduce the likelihood of delays in the dynamic environment of real estate construction.

Figure 3: RII Radar Chart



4.2 Principle component analysis

The analysis of the data using SPSS and the Principal Component Analysis (PCA) method provides valuable insights into the factors contributing to delays in real estate projects in the Pune region. The following matrices explain the underlying structure of the data and the relationships between the variables. Below are the inferences drawn from these matrices.

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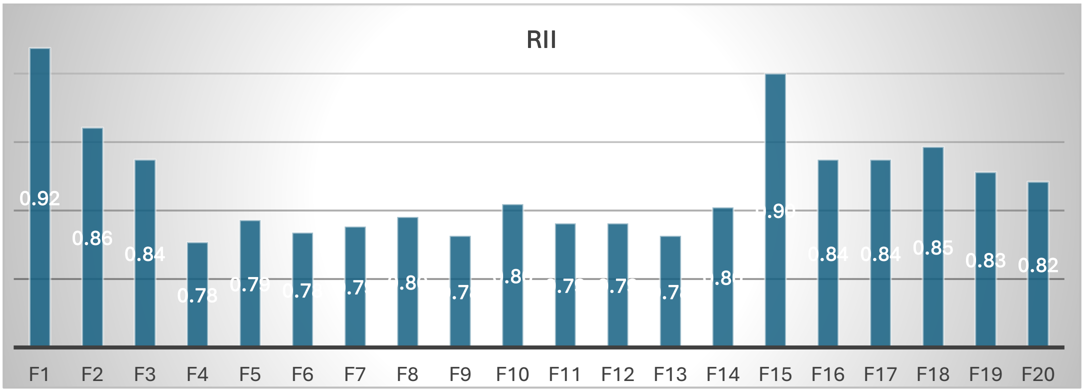
Figure 4: RII Bar Chart



4.2.1. Correlation matrix

The correlation matrix reveals the strength and direction of the relationships between the 20 identified factors causing delays in real estate projects. The matrix shows both positive and negative correlations, indicating how these factors interact with each other. Inadequate Project Planning and Scheduling shows a strong negative correlation with Frequent Changes in Government Policies Affecting Construction (-0.427), suggesting that better planning can mitigate the impact of policy changes. Poor Site Management by Contractors is positively correlated with Delays in Decision-Making by Project Stakeholders (0.408), indicating that ineffective site management often coincides with delays in decision-making. Financial Difficulties Faced by the Contractor are positively correlated with Delays in Payments from Clients (0.097) and Equipment Breakdowns Causing Delays (0.319), highlighting the cascading effect of financial constraints on project timelines.

4.2.2 KMO and Bartlett's test

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.565, which is above the threshold of 0.5, indicating that the data is suitable for factor analysis. Bartlett's Test of Sphericity is significant ($p < 0.001$), confirming that the correlation matrix is not an identity matrix and that the variables are sufficiently correlated for factor analysis. This validates the appropriateness of using PCA to reduce the dimensionality of the data and identify underlying factors.

4.2.3 Total variance explained

The analysis reveals that the first eight components together account for about 68.04% of the total variance in the data, showing a significant chunk of the information is captured by these initial factors. The first component is particularly striking as it alone explains 20.46% of the variance, highlighting its importance. The second and third components also hold substantial

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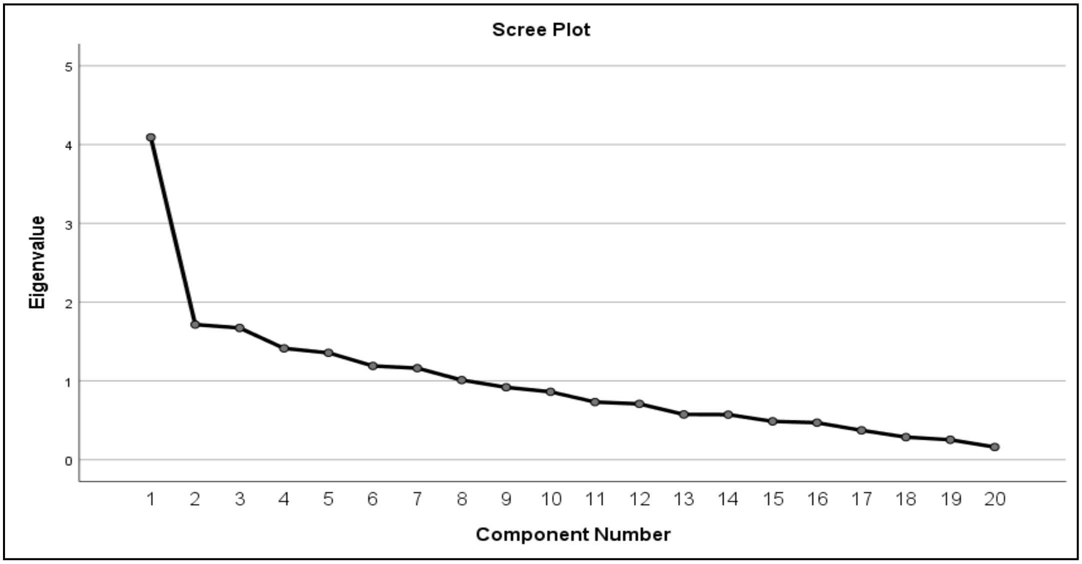
weight, explaining 8.57% and 8.36%, respectively. This pattern indicates that these early components are critical in influencing project delays, with subsequent factors contributing less significantly, thus providing diminishing returns in their ability to explain further variability.

4.2.4 Scree plot (Eigen values vs. component number)

The screen plot, which plots eigenvalues against component numbers, helps in determining the optimal number of components to retain. The plot shows a sharp decline in eigenvalues after the first few components, followed by a gradual leveling off. This "elbow" point typically indicates the number of components to retain. In this case, the plot suggests retaining the first eight components, as they explain a substantial portion of the variance (68.04%), while the remaining components contribute minimally.

Figure 5: Scree Plot



4.2.5 Component matrix

The Component Matrix from the Principal Component Analysis (PCA) is a crucial tool that unveils the relationship between original variables and the principal components derived during the analysis. This matrix helps in understanding the underlying structure of the data by displaying how each original variable contributes to the principal components. Factor loadings within the matrix indicate the strength and direction of these relationships, with higher absolute values showing a significant association with a particular component.

Component 1 Site Management Issues: Poor site management is identified as a primary cause of project delays. Implementing Lean Construction Methods, such as Just in Time (JIT)

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inventory systems, can significantly reduce material waste and site congestion, thus enhancing on-site efficiency (Ansari, 2020). Additionally, real-time monitoring with drones and IoT sensors can track worker productivity and pinpoint inefficiencies (Arantes & Ferreira, 2020). Employing digital tools like Procore and PlanGrid facilitates better documentation and stakeholder communication, crucial for timely project execution.

Component 2 Project Planning & Scheduling Issues: Inadequate planning and scheduling are critical issues, as revealed by PCA. AI-based scheduling software, such as Primavera P6 and Microsoft Project, creates adaptable project timelines that reflect real-time progress and resource availability (Kalkani & Malek, 2016). Early Contractor Involvement (ECI) ensures that contractors are part of the planning and design phases, reducing the need for later redesigns (Ansari, 2020). Including penalty clauses in contracts can also enforce schedule adherence (Sampath & Abeysooriya, 2024).

Component 3 Equipment Related Delays: Equipment reliability is a significant factor. Using RFID and GPS-based tracking systems helps monitor and optimize equipment usage, preventing delays caused by unavailability or malfunctions (Ansari, 2020). AI-driven predictive maintenance can anticipate and prevent equipment failures, thereby reducing project downtime (Arantes & Ferreira, 2020).

Component 4 Regulatory & Approval Delays: Delays due to regulatory processes can be mitigated by adopting streamlined approval systems such as a single-window clearance, which reduces approval times by up to 40% (Sampath & Abeysooriya, 2024). Public-private partnerships and government liaison officers can also expedite these processes, minimizing bureaucratic red tape.

Component 5 Design & Documentation Errors: Errors in design and documentation significantly impact project timelines. Building Information Modeling (BIM) can help prevent such errors by aligning architectural, structural, and MEP models early in the design process, reducing rework and delays (Ansari, 2020). Cloud-based document management systems ensure that all stakeholders have access to the latest design versions, further reducing errors (Kalkani & Malek, 2016).

Component 6 Communication Gaps: Effective communication is essential for project success. Cloud-based collaboration tools like Microsoft Teams and Asana improve real-time communication and coordination among project teams, helping to align project goals and reduce miscommunication (Ansari, 2020).

Component 7 Slow Decision-Making Processes: Slow decision-making can stall projects significantly. Implementing AI-powered project dashboards provides real-time financial tracking and construction progress updates, facilitating quicker and more informed decision-making (Sampath & Abeysooriya, 2024). Establishing clear decision hierarchies allows project managers to handle routine approvals, speeding up the process (Arantes & Ferreira, 2020).

Component 8 Contractor & Subcontractor Issues: The selection and management of contractors and subcontractors are crucial. Pre-qualifying contractors based on their

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performance and financial stability can prevent delays (Ansari, 2020). Performance-based contracts encourage timely completion and hold contractors accountable for delays (Arantes & Ferreira, 2020).

By strategically implementing these mitigation strategies in response to the specific challenges identified through PCA, real estate construction projects can achieve more efficient management, reduced delays, and better overall project outcomes. These targeted approaches, supported by the cited research, provide a robust framework for enhancing project efficiency and effectiveness in the construction industry.

4.2.6 Component correlation matrix

Table 3: Component Correlation Matrix

Component	1	2	3	4	5	6	7	8
1	1.000	-0.137	-0.155	0.141	0.198	-0.017	0.167	0.048
2	-0.137	1.000	0.063	-0.069	-0.077	0.093	-0.126	-0.113
3	-0.155	0.063	1.000	-0.058	-0.116	0.005	-0.130	-0.154
4	0.141	-0.069	-0.058	1.000	0.120	0.014	0.111	0.032
5	0.198	-0.077	-0.116	0.120	1.000	-0.063	0.076	0.075
6	-0.017	0.093	0.005	0.014	-0.063	1.000	0.011	-0.085
7	0.167	-0.126	-0.130	0.111	0.076	0.011	1.000	0.050
8	0.048	-0.113	-0.154	0.032	0.075	-0.085	0.050	1.000

The Component Correlation Matrix serves as a key analytical tool to understand how Principal Components (PCs) relate to one another within a dataset. Each value in the matrix represents a correlation coefficient, indicating the degree of linear association between two components. This is essential for determining whether the components explain distinct aspects of the data or share overlapping variance.

In this matrix, the diagonal values are always 1.0, signifying perfect self-correlation. The off-diagonal values provide insight into the relationships between different components. Values near zero suggest that the components are largely independent, each capturing unique variance within the dataset. A positive correlation above 0.3 indicates a moderate degree of shared information between components, while negative correlations below -0.3 reflect inverse relationships where an increase in one component typically aligns with a decrease in another.

4.3 Observations from the correlation matrix

A moderate correlation is observed between Component 1 (Site Management Issues) and Component 5 (Design & Documentation Errors) with a coefficient of 0.198, suggesting that there may be some overlap in how these issues influence project delays. However, most of the

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other relationships across components are weak or negligible. For instance, Component 1 shows a weak negative correlation with Component 2 (Planning & Scheduling Issues) and Component 3 (Equipment-Related Delays), indicating they capture slightly different patterns of variance. Similarly, Component 2 and Component 3 are mostly independent, with only a very slight correlation (0.063), and minor negative relationships with other components like Component 4 (Regulatory & Approval Delays) and Component 5. These small coefficients suggest that the issues associated with planning, equipment, and regulatory delays operate relatively independently in real-world scenarios. Other components, such as Component 6 (Communication Gaps), Component 7 (Slow Decision-Making Processes), and Component 8 (Contractor & Subcontractor Issues), also show only minimal or weak correlations with the rest—indicating that they represent unique challenges within project management. For example, Component 8 displays very weak correlation with Component 1 and a slight negative correlation with Component 3, further confirming its distinct nature. Overall, the weak inter-component correlations confirm that PCA has successfully differentiated between various dimensions of delay. This reinforces the model's effectiveness in simplifying complex project data while retaining meaningful distinctions between contributing factors, enabling targeted and data-driven interventions in construction project management.

5.0 Conclusion

This study identifies inadequate project planning and ineffective communication among stakeholders as the leading causes of delays in Pune's real estate projects, supported by high Relative Importance Index (RII) scores. Poor scheduling, lack of contingency planning, and fragmented coordination often lead to inefficiencies and work disruptions. Regulatory hurdles, financial constraints, and contractual disputes also significantly impact timelines, underscoring the need for streamlined approvals, better financial management, and clearer contracts.

Through Principal Component Analysis (PCA), the research highlights eight core delay factors ranging from site management to equipment reliability explaining over 68% of data variance. To mitigate these delays, the study recommends integrating advanced tools such as AI-driven schedulers, real-time monitoring systems, BIM, and digital collaboration platforms. Performance-based contracts and contractor prequalification are also emphasized as critical strategies. Technology adoption, particularly in predictive maintenance, digital twin simulations, and blockchain-enabled smart contracts, shows strong potential in enhancing project efficiency. Future research should explore regional variations and the evolving role of emerging technologies in construction project management across India.

References

Ansari, A. M., & Ahmad, S. K. (2019). Study on the causes of delay in a construction project and recommendation. *International Journal of Advance Research and Innovative Ideas in Education, 5*(4), 298–303. http://www.ijariie.com

Antoniou, F., & Tsioulpa, A. V. (2024). Assessing the delay, cost, and quality risks of claims on construction contract performance. *Buildings, 14*(2), Article 333. https://doi.org/10.3390/buildings14020333

Arantes, A., & Ferreira, L. M. D. F. (2020). Underlying causes and mitigation measures of delays in construction projects: An empirical study. *Journal of Financial Management of Property and Construction, 25*(2), 165–181. https://doi.org/10.1108/JFMPC-03-2019-0029

Arantes, A., & Ferreira, L. M. D. F. (2024). Development of delay mitigation measures in construction projects: A combined interpretative structural modeling and MICMAC analysis approach. *Production Planning & Control, 35*(10), 1164–1179. https://doi.org/10.1080/09537287.2022.2163934

Bhavsar, V., Alex, S. T., Vaishnav, P. K., Jose, A., Koshy, N. G., & Atiwadkar, S. (2022). Investigation of critical factors influencing construction of airports: The case of India. *International Journal of Construction Management, 22*(15), 2905–2913. https://doi.org/10.1080/15623599.2020.1831220

Gupta, S., Jha, K. N., & Vyas, G. (2024). Construction and demolition waste causative factors in building projects: Survey of the Indian construction industry experiences. *International Journal of Construction Management, 24*(4), 432–442. https://doi.org/10.10 80/15623599.2022.2111962

Kalkani, K., & Malek, S. (2016). Analyzing causes of delay in construction projects. *International Journal for Innovative Research in Science & Technology, 2*(12), 257–260. http://www.ijirst.org

Le, Y., Shan, M., Chan, A. P. C., & Hu, Y. (2014). Overview of corruption research in construction. *Journal of Management in Engineering, 30*(4). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000300

Nallathiga, R., Shaikh, H. D., Shaikh, T. F., & Sheik, F. A. (2017). Factors affecting the success/failure of road infrastructure projects under PPP in India. *KICEM Journal of Construction Engineering and Project Management.* https://doi.org/10.6106/JCEPM.2017.12.00.001

Prasad, K. V., Vasugi, V., Venkatesan, R., & Bhat, N. S. (2018). Critical causes of time overrun in Indian construction projects and mitigation measures. *International Journal of Construction Education and Research.* https://doi.org/10.1080/15623599.2022.2111962

DOI: 10.17492/JPI/NICMAR/2507074 ISBN: 978-93-49790-54-4

Rauzana, A. (2016). Analysis of causes of delay and time performance in construction projects. *IOSR Journal of Mechanical and Civil Engineering, 13*(5), 116–121. https://doi.org/10.9790/1684-130503116121

Sampath, M. A. V., Abeysooriya, G. O., & Piyashantha, E. A. C. (2024). A case study on factors contributing to time delays of government-funded affordable housing projects: ABC Residencies as a case study in Colombo, Sri Lanka. *Journal of Real Estate Studies, 21*(2). https://doi.org/10.31357/jres.v21i2.7421

Subramani, T., & Rajiv, S. R. (2016). Improving construction efficiency and productivity of industry using SPSS. *International Journal of Application or Innovation in Engineering & Management (IJAIEM), 5*(5), 239–250.