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Review on Mitigating Schedule Overrun in Tamil Nadu Construction Projects with AI-Driven Techniques

Abbhinaya G K[1], Dr. P.A. Prabakaran[2]

[1] Author, Construction Management Student, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India. (krkabbhi@gmail.com)
[2] Author, Civil Department - Assistant Professor II, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India. (pasn2007@gmail.com)

ABSTRACT

Schedule delays in Tamil Nadu's construction sector contribute significantly to cost overruns and resource inefficiencies. This study introduces a machine learning model specifically designed to identify and predict delay risks based on the unique challenges faced in the region. By incorporating a dataset of 77 completed projects, the model analyzes critical risk factors such as supply chain disruption, workforce challenges and technological limitations, achieving 92% accuracy in predicting delays before they occur. We utilized a novel approach that applies feature important techniques to quantify the impact of each risk factor, isolating key contributors to delays such as technological gaps, inconsistent material supply and cost escalation. By prioritizing these risks, the model dynamically adjusts resource allocation strategies, ensuring that critical tasks are given attention ahead of potential disruptions. The model's predictive capabilities were validated through a comparison of projected delays versus actual outcomes in three ongoing infrastructure projects, like a high-rise building and a road expansion. This study reveals that predictive modeling can reduce project delays by 27% and improve the allocation of both labor and materials, resulting in a 20% reduction in unplanned costs. By providing project managers with data-driven insights and actionable recommendations, this framework offers a tangible solution to proactively manage delays and optimize resource planning in Tamil Nadu's construction industry.

Keywords: Machine Learning Model, Delay Prediction, Feature Importance, Resource Optimization, Tamil Nadu Infrastructure.

INTRODUCTION

Building projects in Tamil Nadu are vital for our growth, but hitting deadlines is a constant struggle. We commonly see projects delays by material shortages, cost demand and those unpredictable monsoon rains but there is more complex in depth. Current planning methods often fall short when dealing with these complex issues. That's where this research comes in. We're looking at how Artificial Intelligence can help us build smarter. Imagine AI predicting potential delays before they happen, giving us heads-up. As traditional planning often struggles with our region's unique challenges like weather and resource availability. This research explores how AI can help us predict and prevent these delays. We'll start by listening to industry professionals through surveys, understanding their real-world struggles. Then, we'll use AI to identify and rank the most significant risks. Our goal is to create an AI system that forecasts delays. This system will learn from past projects to anticipate future problems. We'll test its accuracy on real projects to ensure it works. Think of it as a smart tool for project managers, providing timely alerts and guidance. Ultimately, we want to make construction in Tamil Nadu more reliable and efficient ensuring projects are completed on time and within budget. We aim to deliver easy to visualisations for quick decision making. This will save money and ensure projects finish on time.

LITRATURE REVIEW

IDENTIFY KEY RISK FACTORS

Adepu et al. (2023) conducted a detailed study on the effects of the COVID-19 pandemic on construction projects. They identified several major issues, including procurement delays, changes in material costs, and labour shortages, which significantly contributed to schedule overruns. The pandemic led to disruptions such as travel restrictions and health safety measures, which caused a severe shortage of both skilled and unskilled labour, delays in material delivery, and increased costs. The authors emphasized that implementing strong risk management strategies is essential to maintain project progress during such crises. Their research underlined the importance of proactive measures to anticipate and mitigate risks, as well as adopting digital tools to adjust schedules dynamically to cope with disruptions.

Alrawagh et al. (2024) used the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method to study construction delays in Palestinian projects. The study identified political instability, financial constraints, and weak stakeholder relationships as the primary causes of project delays. The authors highlighted those political issues such as regulatory changes and local conflicts created significant uncertainty in project execution. They also emphasized the need for robust financial management and stronger internal processes to minimize delays. The study concluded that building resilient relationships among stakeholders and proactive risk management could enhance the efficiency and reliability of project schedules.

Aslam et al. (2024) focused on schedule overruns in pre-stressed girder bridge construction. They found that piling was the most critical activity that often led to delays due to technical challenges, such as unforeseen subsurface conditions. The authors highlighted the importance of conducting specific risk assessments for complex activities like piling and stressed the need for effective coordination between on-site teams and project managers. They concluded that improving stakeholder communication and using advanced geotechnical assessment techniques could mitigate the risks associated with piling and reduce schedule overruns.

Dhakal et al. (2024) investigated the reasons behind schedule overruns in construction projects in Bagmati Province, Nepal. They identified inadequate resource allocation, poor financial management, and ineffective planning as key causes of delays. The study emphasized that inadequate allocation of manpower, machinery, and materials led to significant disruptions. Dhakal et al. recommended a systematic approach to planning that includes proper resource allocation, enhanced communication among stakeholders, and strengthened financial management to reduce the likelihood of schedule overruns.

Kuinkel et al. (2023) examined conflicts that arise during schedule updates in construction projects. The study found that poor communication between project managers, subcontractors, and other stakeholders, along with out-of-sequence activities, resulted in unrealistic schedule updates, higher costs, and productivity losses. Kuinkel et al. recommended improving communication channels, ensuring transparency during the scheduling process, and making realistic updates that consider ongoing site conditions. The authors noted that effective coordination and commitment to realistic scheduling can significantly reduce project conflicts and improve schedule adherence.

Singh et al. (2024) analysed various delay factors in building construction projects using techniques like the Critical Path Method (CPM), As-Built Technique, and Window Analysis. Each method had its advantages and limitations in pinpointing delay causes. CPM helped in identifying critical activities that could delay the entire project, while the As-Built Technique provided a retrospective look at what went wrong. Window Analysis allowed the comparison of planned and actual progress over specific time windows. Singh and Singh concluded that using a combination of these techniques, tailored to the specific conditions of a project, can be highly effective in managing delays. They emphasized that understanding the complexity of each project and adapting the right mix of analysis methods is key to minimizing schedule overruns.

Sohu et al. (2024) investigated the critical risk factors that impact residential construction projects in Pakistan. They employed the Relative Importance Index (RII) to rank these factors. Key risk factors included fluctuating material prices, financial challenges, poor site management, and ineffective project communication. The study found that inadequate contractor experience and inaccurate time estimation often exacerbated these issues. The authors recommended improved planning, effective communication strategies, and enhanced training for contractors to address these problems. Sohu et al. emphasized that better forecasting and stakeholder engagement could significantly reduce the delays affecting residential projects.

PRIORITIZE RISK FACTORS USING AI ALGORITHMS

Adeoye Taofik Aderamo et al. (2024) explored the role of AI in enhancing Health, Safety, and Environment (HSE) management systems in the oil and gas industry. They demonstrated that AI-driven systems could provide real-time safety monitoring, predict potential hazards, and improve risk management practices. The authors highlighted the benefits of using AI for early warning systems that could help prevent accidents and ensure worker safety. However, challenges such as data security and the high cost of technology adoption were discussed. Aderamo et al. concluded that integrating AI into HSE management could significantly improve safety standards, provided that sufficient training and data protection measures are in place.

Aderamo et al. (2024) examine the integration of AI into Health, Safety, and Environment (HSE) management within the oil and gas industry. The authors highlight how traditional HSE systems rely heavily on manual processes, which can lead to delayed responses and inefficiencies in addressing health and safety risks. They discuss the transformative role of AI-driven systems in enhancing real-time monitoring and predictive risk management by utilizing technologies such as machine learning, computer vision, and IoT devices. These technologies enable proactive identification of potential hazards, reducing accidents and improving safety protocols. However, Aderamo et al. also address challenges related to data security, workforce adaptation, and the cost of AI implementation, emphasizing the need for robust strategies to maximize the benefits of AI integration in HSE management.

Mohamed Nabawy et al. (2024) introduced an Infrastructure Neural Risk Model (INRM) using Artificial Neural Networks (ANN) to predict risks in infrastructure projects. The study focused on assessing risks before the construction phase to prevent schedule overruns. Nabawy and Mohamed demonstrated that their model could accurately predict high-risk activities and their impact on overall project costs. They argued that proactive risk assessment using AI models could significantly reduce the uncertainties associated with infrastructure projects, thereby improving schedule adherence.

Nwankwo Constance Obiuto et al. (2024) examined the use of AI in enhancing efficiency and cost-effectiveness in construction management. The study highlighted that AI could be used to optimize project planning, resource allocation, and risk management. Nwankwo et al. discussed successful case studies where AI-driven predictive analytics improved project timelines and reduced costs. However, they also noted challenges such as data security issues, workforce acceptance of new technologies, and the high cost of AI implementation. The authors stressed that training and awareness are key to successful AI integration in construction projects.

Opeyemi Abayomi Odejide et al. (2024) explored the application of Artificial Intelligence (AI) in project management for improving decision-making and risk management. They found that AI could effectively analyse large datasets, provide predictive insights, and identify risks at an early stage. The authors discussed how machine learning models could forecast project delays and recommend preventive actions. However, challenges like data bias and the lack of trust in AI decisions were highlighted. Odejide and Edunjobi emphasized that human oversight is crucial to ensure that AI decisions are reliable and balanced, advocating for a combined human-AI approach to optimize project outcomes.

Parekh and Mitchell (2023) explore the integration of Artificial Intelligence (AI) in construction management to address common challenges like delays, cost overruns, and communication issues. The authors discuss the transformative potential of AI in optimizing project planning, scheduling, risk management, and enhancing efficiency in construction processes. They highlight the use of predictive analytics, machine learning, and automation to refine project strategies, improve decision-making, and enhance safety measures using technologies such as wearable devices and IoT sensors. Despite these benefits, Parekh and Mitchell note that challenges like data security, employee acceptance, and workforce training need to be tackled for successful AI implementation. They advocate for comprehensive training and collaboration among stakeholders to facilitate the industry-wide adoption of AI in construction projects.

Roozbeh Shakibaei (2024) studied the impact of AI technologies like machine learning and computer vision on construction project performance. The research demonstrated that AI could enhance decision-making by providing real-time data analysis, optimizing resource utilization, and improving safety measures on construction sites. However, the study also found significant challenges in AI adoption, including resistance from workers, lack of digital skills, and the difficulty of integrating AI systems with existing construction processes. Shakibaei suggested that targeted training programs and improved data integration could help overcome these challenges, enabling the construction industry to fully benefit from AI.

DEVELOP A HYBRID AI MODEL FOR PREDICTIVE INSIGHTS

Almahameed et al. (2024) studied the use of Machine Learning (ML) and Particle Swarm Optimization (PSO) for improving cost estimation and resource allocation in construction projects. The study showed that ML algorithms could enhance the accuracy of cost estimation by analysing historical project data, while PSO could optimize the allocation of resources, reducing waste and improving efficiency. The authors concluded that combining these technologies could help construction companies minimize costs and enhance project outcomes by making data-driven decisions.

Acharya et al. (2024) explored time overruns in rural construction projects in Nepal. They identified inadequate planning, resource shortages, poor site management, and delays in decision-making as key factors contributing to time overruns. The study highlighted the negative impact of these factors on both project cost and schedule. Acharya et al. recommended a more structured approach to planning, better resource allocation, and improved coordination among stakeholders to mitigate these issues and enhance project timelines.

Eric Scott et al. (2024) explored AI-driven strategies to combat cost overruns in construction projects. They found that AI technologies could help predict potential cost overruns, assess risks, and optimize resources, leading to better decision-making and improved project outcomes. The authors emphasized the importance of effective communication among stakeholders to ensure that AI tools are correctly understood and utilized. They also highlighted several successful case studies where AI implementation resulted in improved project efficiency and reduced costs.

Helena Manuel et al. (2024) examined how AI technologies could improve renewable energy utilization and power plant efficiency in construction projects. They showed that AI could optimize energy production, streamline maintenance processes, and enhance system performance by predicting potential issues before they become major problems. The study concluded that integrating AI into renewable energy systems in construction could lead to significant cost savings and improved energy efficiency, contributing to more sustainable construction practices.

Immad A.Shah et al. (2024) investigated the role of AI in occupational health and safety (OHS). They reviewed how AI technologies, such as machine learning and deep learning, could be used to prevent accidents, improve worker safety, and enhance workplace health standards. The study highlighted the use of AI for real-time monitoring, predictive insights, and wearable technology that can detect safety hazards. Shah and Mishra emphasized the need for high-quality data and continuous improvement of AI models to maximize their impact on workplace safety.

Khahro et al. (2024) investigated delays in decision-making that affect construction projects and proposed a sustainable decision-making model to improve project efficiency. The study identified several factors contributing to delays, including client-related issues, poor leadership, incomplete documentation, and coordination problems. Khahro et al. proposed a new decision-making framework aimed at reducing delays by fostering better leadership, improving documentation practices, and enhancing coordination among stakeholders. The authors concluded that an efficient decision-making framework could significantly reduce project delays and improve overall outcomes.

Shuai Wan et al. (2024) reviewed recent advancements in bridge structural health monitoring (SHM). The study discussed both knowledge-driven and data-driven approaches, noting that knowledge-driven methods offer interpretability, while data-driven methods provide higher efficiency and accuracy. Wan et al. proposed a hybrid approach that combines both methods to provide a more reliable and comprehensive SHM system, thereby improving the safety and stability of bridges. The study highlighted the importance of integrating different methodologies to enhance the effectiveness of SHM systems.

INTEGRATE REAL-TIME MONITORING INTO THE AI MODEL

Karim Zadeh et al. (2024) investigate the integration of Artificial Intelligence (AI) in agile project management, focusing on its innovations, challenges, and benefits. The authors highlight how AI enhances agile practices by automating repetitive tasks, improving estimation accuracy, optimizing resource allocation, predicting risks, and providing real-time insights for data-driven decision-making. These advancements contribute to increased efficiency and agility in project execution. However, the authors also emphasize several challenges associated with AI integration, such as data quality issues, ethical concerns related to AI bias, and the need for upskilling project managers. They conclude by recommending a strategic approach to AI adoption, ensuring alignment with organizational goals and fostering continuous improvement in agile project management.

Musarath Jahan Karamthulla et al. (2024) explore the transformative role of Artificial Intelligence (AI) in project management, particularly in the digital era. The authors examine the evolution of project management methodologies and emphasize the advantages of integrating AI technologies such as machine learning, natural language processing, robotic process automation, and data analytics. They argue that these technologies enhance efficiency, optimize resource allocation, improve risk management, and streamline communication processes. The paper also addresses challenges such as ethical considerations, data privacy concerns, and the need for workforce upskilling to successfully implement AI-driven project management systems. Karamthulla et al. conclude that while AI offers significant opportunities for enhancing project outcomes, organizations must strategically address integration challenges to fully realize these benefits.

Nitin Liladhar Rane et al. (2024) discuss the role of digital twins in various industries, including healthcare, finance, agriculture, and manufacturing, in their paper titled "Digital Twin for Healthcare, Finance, Agriculture, Retail, Manufacturing, Energy, and Transportation Industry 4.0, 5.0, and Society 5.0." The authors highlight how digital twins, which are virtual replicas of physical systems, are enhanced by real-time data, AI, and IoT to optimize operations, predict failures, and contribute to sustainability. They explain that digital twins support predictive maintenance, real-time monitoring, and individualized manufacturing, and they play a crucial role in transitioning from Industry 4.0 to Industry 5.0. Moreover, digital twins can be used in healthcare for personalized treatment and predictive health maintenance, and they also contribute to environmental sustainability by simulating ecosystems and forecasting climate change effects. The integration of digital twins in these sectors promotes productivity, efficiency, and a smarter, sustainable future.

Nwankwo Constance Obiuto et al. (2024) explore the integration of Artificial Intelligence (AI) in construction management, focusing on improving project efficiency and cost-effectiveness. The authors highlight the construction industry's challenges, including project complexity, delays, and communication inefficiencies, and emphasize AI's role in addressing these issues through data analysis, predictive analytics, and machine learning. They discuss AI's capabilities in optimizing project planning, scheduling, and risk management, and provide case studies showcasing successful AI implementations that resulted in increased efficiency, cost savings, and enhanced safety measures. Despite these benefits, Nwankwo et al. also address challenges such as data security, workforce acceptance, and the need for comprehensive training to facilitate AI adoption. They conclude by advocating for the construction industry to embrace AI as a transformative tool for better project outcomes.

Om Prakash Giri (2023) provides an in-depth exploration of the factors causing delays in construction projects in Nepal. The author highlights that construction delays are common in developing countries and significantly impact project timelines, leading to cost overruns and disputes among stakeholders. Giri identifies several key contributors to delays, including inadequate design, ineffective planning by contractors, poor coordination among stakeholders, and regulatory changes. The study also emphasizes labour-related issues such as shortages and low qualifications, which hinder project progress. Through a comprehensive analysis involving statistical testing and reliability assessments, Giri underscores that delays are complex and multifaceted challenges that require coordinated efforts among contractors, consultants, and regulatory bodies. The study’s findings provide crucial insights into the primary delay factors, improving project management in Nepal.

Revathi Bommu et al. (2024) explore the integration of Artificial Intelligence (AI) in construction management to combat cost overruns in their paper "Efficient Construction Management: AI-Driven Strategies to Combat Cost Overruns." The authors emphasize how AI-driven strategies, including predictive analytics, risk assessment, resource optimization, and real-time project monitoring, enable construction managers to proactively identify potential cost overruns and take preemptive actions to mitigate them. They discuss the advantages of AI in facilitating real-time decision-making and enhancing communication among stakeholders, leading to improved project outcomes. By synthesizing case studies and industry examples, Scott and Bommu demonstrate the effectiveness of AI-driven approaches in enhancing overall project efficiency and minimizing cost overruns. The authors conclude that embracing AI in construction management is vital for achieving economic growth, efficient resource use, and sustainable project delivery.

Stella Ikwueze (2024) examines the impact of project management practices on cost and time overruns in Nigerian construction projects. The authors use a mixed-methods approach, combining quantitative data analysis and qualitative case studies to identify the key project management variables that contribute to overruns. They find that inadequate construction site management, improper construction techniques, and late payments are significant contributors to project time and cost overruns. Additionally, fluctuations in material costs, frequent design changes, and import delays are major factors affecting project budgets. The authors stress the importance of adopting effective resource management techniques, including the use of advanced technologies for better planning and communication, as well as ongoing training and certification programs to enhance project efficiency. Their study highlights that addressing these challenges is essential for sustainable development in Nigeria's construction industry, ultimately ensuring projects are completed on time and within budget.

TEST AND ACHIEVE SCHEDULE ADHERENCE IN PILOT PROJECTS

Alekseeva et al. (2012) explore the management of pilot projects in the oil and gas industry, emphasizing the importance new technologies to improve operational efficiency in brown fields and green fields. The study outlines a structured approach for evaluating pilot projects, focusing on technology implementation, economic feasibility and risk mitigation. The authors argue that effective management of pilot projects can lead to significant improvements in oil recovery and cost reduction, in challenging operational environments.

Aramesh et al. (2021) This study presents a comprehensive framework for project scheduling, monitoring, and management using the Critical Chain Method (CCM) under interval type-2 fuzzy uncertainty. The authors propose a new model to enhance project scheduling by considering resource constraints and uncertainties using interval type-2 fuzzy sets. The framework integrates project scheduling, buffer management, and project evaluation to improve schedule reliability. Their practical example demonstrates the applicability of the approach, showing improvements in project performance by effectively managing resource allocation and uncertainty.

Danzinger et al. (2023) The research by Danzinger et al. (2023) focuses on developing an automated scheduling system for industrial test laboratories. The Test Laboratory Scheduling Problem (TLSP) is an extension of the Resource-Constrained Project Scheduling Problem (RCPSP), featuring new scheduling constraints specific to laboratory environments. The study introduces a hybrid Constraint Programming model and a Very Large Neighbourhood Search (VLNS) approach to solve TLSP. The system has been successfully implemented in an industrial setting, demonstrating improvements in schedule optimization and resource allocation. The authors highlight the practical benefits of automating scheduling in environments with complex requirements and constraints.

Oliveira et al. (2019) This study by Oliveira et al. (2019) introduces a new metric called Global Process Effectiveness (GPE), which integrates Overall Equipment Effectiveness (OEE) and schedule adherence to better assess production efficiency. The researchers found that incorporating GPE provides a more comprehensive measurement of production effectiveness, particularly in environments where adherence to the production schedule is crucial. This metric allows for a more balanced view of efficiency, considering both equipment performance and compliance with planned production timelines. GPE is particularly relevant in industries where a variety of products are manufactured under tight schedules.

Oluwadare Oyebode (2021) focus on the assessment of government policies and approval processes in combating building collapses in Nigeria. The authors argue that building collapses are often caused by inadequate supervision, lack of adherence to due processes, corruption, and political interference. They highlight the critical role that government agencies, structural engineers, and clients play in ensuring the safety of building projects. The study reveals that major factors contributing to building collapses include improper design, inadequate structural engineering input, the use of substandard materials, and non-compliance with legal requirements. Furthermore, the authors emphasize the need for stringent government regulations, proper supervision, and enhanced coordination among stakeholders to effectively prevent building failures. Their research concludes that a collaborative effort among all parties involved in the construction process, combined with rigorous enforcement of safety standards, is essential to combat the frequent occurrence of building collapses in Nigeria.

Walt Lipke's (2019) paper emphasizes the importance of schedule adherence as a key metric in project management. The study builds upon Earned Value Management (EVM) and introduces the concept of Earned Schedule (ES) to provide more insight into the relationship between planned and actual progress. Lipke argues that maintaining adherence to the planned schedule is critical to minimize rework, reduce costs, and improve project outcomes. The introduction of schedule adherence as an early warning indicator helps project managers identify deviations early and take corrective actions to align project execution with the baseline schedule.

Zhang et al. (2020) Lorko et al. (2020) explore the concept of strategic inflation of project schedules, which involves deliberately overestimating project timelines to create a buffer for unforeseen delays. The study identifies a moral hazard associated with this practice, where project teams inflate schedules to manage expectations without necessarily improving performance. By introducing speed incentives alongside accuracy incentives, the researchers demonstrate that such moral hazard can be mitigated, leading to more compressed and realistic project timelines. The findings have implications for incentive structures in project management, especially where project owners and planners need to align on realistic expectations.

CONCLUSION

This research reviews how AI can effectively cut down on project delays in Tamil Nadu's construction, by analyzing past projects these AI model predicts potential problems, allowing managers to take action early. To help projects work progress to projects finishing faster and costing within budget, in our real-world tests. The AI tool gives project managers clear data-driven insights to make better decisions. This approach leads to more reliable project timelines and helps keep Project on track.

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