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INVESTIGATING FACTORS IN CONSTRUCTION WORKFLOW INFLUENCING WASTAGE IN PUBLIC INFRASTRUCTURE PROJECTS: A CASE STUDY IN VISAKHAPATNAM, INDIA

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Abstract

Construction waste management remains one of the pivotal and widely discussed topics within the construction industry. The global demographic surge, escalating land scarcity, and mounting demand for new housing, amenities, and infrastructure. While it necessitates a vast amount of material and energy inputs, imposing intense strain on natural resources. As a dominant consumer of these resources, the construction sector is often criticized for its High-volume generation of construction waste, which adversely degrades the environment, affecting human health, aquatic biodiversity, and air quality. This study aimed to identify the main factors in construction workflows that lead to waste in public infrastructure projects in Visakhapatnam, India. A mixed-method approach is used, combining a quantitative survey (N = 80), interviews, and an extensive literature review to analyze projects managed by the public construction organization. The reliability test of the questionnaire showed Cronbach's Alpha values between 0.83 and 0.86. Data were collected from key stakeholders such as site engineers, contractors, and project managers. The descriptive analysis revealed that inefficiencies are common across all seven workflow areas examined, with average scores ranging from 3.75 to 4.14 on a five-point scale. The main factors contributing to waste are Workforce & Skills (M = 4.14) and Design & Documentation (M = 4.07), highlighting issues such as skill shortages, communication gaps, design errors, poor coordination, and frequent changes in order as primary causes of waste. The analysis also shows that the adoption of lean construction strategies and practices is limited in public projects. A multiple regression analysis was conducted to assess the direct impact of these factors on the implementation of lean practices. The results indicate that Design & Documentation is the only significant factor ($B = 0.297$, $p<0.05$) influencing a project's ability to adopt lean principles. This emphasizes that resolving design-related issues is crucial for the successful implementation of lean construction methods, thereby maximizing value and minimizing waste. The study offers practical recommendations to address these factors through lean construction principles. Key strategies include strengthening the design and planning phases to reduce errors and changes; improving on-site supervision and workforce skills through targeted training; and implementing structured material management and waste recycling systems. Consequently, this study provides a structured framework for public authorities and practitioners to improve project efficiency, maximize value, and minimize waste through collaboration and continuous improvement.

Keywords: Waste Management, Lean Construction, SPSS, Public Construction Projects, Workflow Inefficiencies, Factors Influencing Waste Generation, Design Management, Maximizing Value, Minimizing Waste, And Multiple Regression Analysis.

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INTRODUCTION

Public construction projects, such as buildings, roads, and infrastructure, are essential for economic development and public amenities. However, the construction sector, due to poor workflow and coordination, often experiences substantial resource wastage during the construction process. Globally, the construction industry accounts for approximately 30% of total solid waste generation, and this inefficiency in workflow leads to a 40% increase in material costs Aftab et al, 2025. Such inefficiency and wasteful practices directly result in project underperformance: studies show that preventable construction waste is the primary cause of cost overruns, which are estimated to be more than 10% of the budget, and cause delays, rework, and reduced quality Alotaibi, et al, 2025 and Janani et al, 2022. These issues pose a serious problem in publicly funded projects, where resource wastage results in the loss of taxpayers' money and delays in public benefits.
India's significant investment in infrastructure has brought attention to construction management waste. Recent studies on Indian construction highlight several factors that influence waste generation, including poor planning, inadequate coordination of equipment, materials, and labor on site, poor workmanship, improper storage and handling of materials, and rising material costs Dera et al. 2024. Public construction projects are especially prone to these issues due to their large scale, multiple stakeholders, and complex regulatory processes. Visakhapatnam (Vizag), a coastal city in Andhra Pradesh, India, is known for rapid development. The Visakhapatnam Metropolitan Region Development Authority (VMRDA), which manages regional development, oversees various projects from road networks to public buildings, making it an ideal example to identify inefficiencies in construction workflows that could lead to waste.

This paper examines the factors within construction workflows that lead to wastage in publicly funded projects, focusing on VMRDA and its projects in Visakhapatnam as a case study. By integrating insights from existing literature with data collected through Google Form questionnaires and interviews, the study aims to identify the root causes of waste in construction workflows and propose solutions, best practices, or strategies to enhance efficiency in public construction projects.

Research Objectives & Goals

Goal: To identify and analyze construction factors in the workflow that influence waste generation in publicly funded projects in Visakhapatnam, India, and recommend measures to reduce waste.

Objectives:

To evaluate and analyze the main workflow factors influencing waste generation in public construction projects in Visakhapatnam, India. To examine how key operational factors like planning, design, coordination, workforce, material handling, and external influences impact waste generation in public infrastructure projects. To conduct statistical analyses, validate the effects of these factors on project inefficiencies, and determine the relationship between these factors and inefficiency using the collected data. To propose

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solutions based on lean construction principles that can help reduce the key waste factors identified in public projects.

LITERATURE REVIEW

Construction Waste in Public Projects: Waste in workflow refers to any resource, procedure, or activity used during project execution that does not add value to the final project; this includes material waste, time, labor, effort, and costs. Many studies confirm that these types of waste significantly affect project outcomes. For instance, unnecessary material waste on construction sites is an avoidable task that can increase the project budget by more than 10% of the planned cost. Alotaibi et al. 2025. Additionally, waste and rework often lead to schedule delays and lower quality of the final product due to rushed, corrective, and reactive work. Janani, et al. 2022. Public infrastructure projects, with their large budgets and strict timelines, are particularly vulnerable to overruns. Cost increases, delays, and inefficiencies in public projects deplete financial resources and erode public trust.

Prior research provides evidence that the reduction of waste is a critical factor in the successful completion of a project. For instance, collaborative or pull planning aims to enhance value-adding activity while reducing or eliminating non-value-adding tasks, which can lead to better planning, scheduling, and reduction of time and cost overrun. Imimole et al. 2018. Based on the studies and the industry surveys, due to poor performance and inefficiency in work procedures account for nearly 10% of all project spending. Sweis, R. et al. 2021. Therefore, finding the root causes of inefficiency and waste factors in work procedures is an important step toward sustainability and accountability of public construction projects.

Key Factors Influencing Construction Waste

Poor planning & Scheduling: Poor planning is identified as one of the major causes of waste generation. When the project schedules are unrealistic and plans are incomplete, misalignment occurs between the design and execution, often resulting in idle resources and last-minute adjustments. Inefficient planning is a significant contributor to high waste generation and project delays. Nagapan, S. et al. 2011. Additionally, the bureaucratic process in public projects is also a primary challenge that disrupts the schedule and worsens the problem.

Changes and Errors in Designs: Design-related problems lead to rework and material wastage. Studies show that errors and design changes often result from shifts in client requirements or mistakes in drawing, which are among the main factors of waste Jusoh, et al., 2016. And Nagapan et al. 2011 noted that design changes were the primary source of waste in their analysis, causing complete demolition of the work and the need for additional time, effort, and material waste. Olanrewaju. Et al. 2020. Similarly, a recent study indicates that the changes and complex design are the main causes of waste in mega-projects. PMI. 2018. Managing design changes in public projects is a critical factor due to stakeholder feedback or political mandates.

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Poor Coordination and Communication: The Construction sector is inherently a multi-disciplinary field, involving architects, engineers, contractors, and consultants. Weak coordination leads to idle time, duplicated work, delay, and errors. Poor coordination is a key factor in waste generation in complex projects Luangcharoenrat et al. 2019. In India, A study on construction projects shows that poor site coordination among the team is the primary source of wastage in construction Doloi, et al. 2012. Public projects have a complex stakeholder network, such as government departments and external consultants; therefore, the clear communication channels are an important factor to prevent waste.

Lack of Supervision and Management Control: Insufficient oversight at the construction site can result in unreliable work and overlooked mistakes. When issues are not caught early, it often leads to rework. A case study analysis of Saudi Arabia's mega-projects highlights the lack of supervision as one of the major factors contributing to waste, PMI, 2018. In public projects, strong project management practices are vital to ensure that the team follows the plan and quality standards, thereby minimizing rework or the need for do-overs.

Low Skill and Poor Workmanship: The skill and awareness of the workforce are essential factors in waste management. An unskilled and insufficiently trained workforce is susceptible to rework to rework, and mistakes could lead to material misuse, idle time, and wasted effort. Aftab et al. 2025, noted that lack of awareness, training, and poor workmanship are the main contributors to waste generation in developing countries, EZE, et al. 2021. In the Indian context, the study highlights poor workmanship as a major challenge and a significant cause of material waste Fromsa, et al. 2020. Public projects involving large workmanship and multiple contractors should invest in training and enforce strict quality control to prevent problems.

Material Handling and Storage: Proper storage and handling of material are crucial for preventing unnecessary movement, damage, theft, and spoilage. A study shows that improper on-site material storage and handling are among the top-most effective waste factors Mokhtar, et al. 2011.

Procurement and Supply Chain: Procurement and supply Chain play an important role in waste prevention. Issues such as incorrect order, specification, time, quality, quantities, delivery delay, and damaged goods can severely impact the project outcome if not managed carefully. Alotaibi et al. 2025, acknowledged that in their studies, procurement and supply chain mistakes are a key factor in waste generation in large projects PMI, 2018. Public sector procurement based on rules and policy may sometimes force the choice of the lowest bids or eligibility, which can affect the quality issues if not managed closely and carefully.

Inefficient Waste Management Practices: A structured and enforceable waste management framework is essential for eliminating waste. The absence of proper sorting, reusing, and recycling policies leads to unnecessary material loss. Studies from Egypt and Saudi Arabia in construction projects show that poor practices and lack of waste

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management culture are the primary key to wastage Kineber, et al. 2024, and Ouda, et al. 2018. While this highlights the need for effective policy intervention and the public project must mandate waste management policy and have strict oversight and control.

Financial and External Factors: Financial stability is crucial for the successful completion of projects. Cost escalation and sudden price increase, or budget cut, can slow down the work process or force the use of cheap, low-quality material, which leads to waste generation. A recent study on Indian construction waste management found price escalation to be among the top causes of wastage Tayyab, et al., 2023. Other external factors, such as bad weather, site conditions, theft, or vandalism, are noted as contributors to the loss of time, material, and effort. Although these factors are not fully controllable but a structured risk mitigation plan could help, such as protecting materials from bad weather and insurance against price and cost fluctuations, to reduce their impact. These factors are not isolated but correlate and interact with each other; for instance, late change in design interrupts the work procedure, disrupts the schedule, and triggers rushed execution, leading to worker error, resulting in material wastage and rework.

Public Projects in Visakhapatnam: Study Context

Visakhapatnam, also known as Vizag, is a coastal city experiencing rapid infrastructure development. The city is grappling with multifaceted challenges, including severe environmental challenges such as high humidity, saline air, and cyclones, as well as administrative hurdles like conventional management systems, inefficient supply chains, bureaucratic issues, complex procedures, strict budget constraints, and pressure to meet deadlines, scrutiny on quality and transparency, shortages in material supply, and delays in funding. For example, the Rushikonda Palace project faced allegations of significant environmental violations. VMRDA (Visakhapatnam Metropolitan Regional Development Administration) is a public-funded organization responsible for the planning and sustainable development in Vizag. This study investigates public construction projects in Vizag, such as VMRDA, as a small-scale example in India's large public infrastructure development. Aiming to find out the factors influencing waste generation in workflow within public infrastructure projects. In the next section, the data collection methodology is explained how data is collected and analyzed to meet the research objectives.

RESEARCH METHODOLOGY

In this study, a mixed-methods approach is used to investigate construction workflow factors influencing water generation in public infrastructure. VMRDA is selected as a case study which publicly funded construction projects, responsible for planning and regional development in Visakhapatnam. A structured questionnaire was developed based on insights obtained by site visits and stakeholder meetings. Subsequently, the questionnaire was built using Google Forms and distributed among construction managers and site engineers associated with public projects. The survey focused on factors influencing wastage, such as workflow inefficiencies, waste management methods, and strategies.

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Moreover, a comprehensive study was carried out to review papers, articles, and literature to understand or contextualize findings to determine the best practices in public infrastructure.

The analysis of the quantitative data was employed using SPSS to determine patterns, correlations, and the key inefficiency factors. Descriptive statistics and tests such as regression analysis, cross-tabulation) were used to evaluate the relationship between construction practices and waste generation.

Research Gap

Existing studies have mainly centered on solid waste management, often overlooking the workflow inefficiencies, which are the primary factor for solid waste generation; only a few studies mostly have partially addressed workflow.

RESULTS AND DISCUSSION

- **Reliability Statistics**

The reliability test results of the questionnaire were conducted to analyze factors influencing waste generation in public infrastructure workflows. A reliability analysis was conducted using SPSS. Cronbach's alpha was used to determine the internal consistency of the questionnaire, which included 35 questions across seven thematic categories. The alpha values ranged above 0.8, indicating high internal reliability Nunnally and Bernstein, 1994. According to previous research and references, $\alpha \geq 0.9$ indicates excellent reliability, $0.8 \leq \alpha < 0.9$ shows very good reliability, $0.7 \leq \alpha < 0.8$ is acceptable, and $\alpha < 0.7$ indicates that the data is not reliable and not suitable for further analysis.

Table 1: Reliability Statistics

No	Construct / Scale	Items (N)	Alpha
1	Planning & Scheduling (Q1–Q5)	5	0.84
2	Design & Documentation (Q6–Q10)	5	0.84
3	Coordination & Supervision (Q11–Q15)	5	0.86
4	Workforce & Skills (Q16–Q20)	5	0.83
5	Material Handling & Procurement (Q21–Q25)	5	0.87
6	External & Financial (Q26–Q30)	5	0.83
7	Waste & Lean Practices (Q31–Q35)	5	0.86

The analysis of table 1 confirmed that all seven constructs used in the questionnaire demonstrate high internal consistency, with Alpha values ranging from 0.83 to 0.87. Specifically, Planning & Scheduling ($\alpha = 0.84$), Design & Documentation ($\alpha = 0.84$), and Coordination & Supervision ($\alpha = 0.86$) showed strong reliability, indicating that these items reliably measured project inefficiencies within their respective domains. The Workforce & Skills scale ($\alpha = 0.83$) was also consistent, confirming reliable responses related to training, skills, and fatigue. Similarly, Material Handling & Procurement ($\alpha = 0.87$) exhibited excellent reliability, emphasizing the significance of supply chain inefficiencies as key contributors to wastage. The External & Financial factors ($\alpha = 0.83$) scale was found to be reliable as well, capturing pressures such as approval delays, cost

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fluctuations, and payment issues. Finally, the Waste & Lean Practices construct (α = 0.86) demonstrated very good reliability, confirming that lean-related practices like Just-in-Time, 5S, and waste monitoring were consistently assessed. Overall, these results indicate that the questionnaire is a robust and statistically dependable instrument, suitable for assessing workflow inefficiencies and the adoption of lean practices in publicly funded projects

- **Frequency Analysis**

Table 2: Frequency Statistics Using SPSS

Role					
Role		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Consultant	16	20.00	20.00	20.00
	Contractor	25	31.30	31.30	51.20
	Project Manager	12	15.00	15.00	66.30
	Site Engineer	27	33.80	33.80	100.00
	Total	80	100.00	100.00	

Experience					
Experience		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	<5 years	12	15.00	15.00	15.00
	>15 years	15	18.80	18.80	33.80
	11–15 years	25	31.30	31.30	65.00
	5–10 years	28	35.00	35.00	100.00
	Total	80	100.00	100.00	

Project Type					
Project type		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Building	26	32.50	32.50	32.50
	Infrastructure	13	16.30	16.30	48.80
	Mixed	12	15.00	15.00	63.70
	Road/Highway	29	36.30	36.30	100.00
	Total	80	100.00	100.00	

Demographic analysis in table 2 shows that the study responded are professionals in the operational sector while they are involved in daily construction activities on publicly funded projects. These individuals are well-placed to observe workflow inefficiencies and waste. The respondent group mainly includes site engineers (33.8%), followed by contractors (31.3%), consultants (20.0%), and project managers (15.0%). Participants with 5–10 years of experience form the largest group at 35.0%, with those having 11–15 years accounting for 31.3%. The 15-year experience group makes up 18.8%, while those with 5 years of experience account for 15%. Most participants have between 5 and 15 years of experience (66.3%), which supports the credibility of the findings given their significant project expertise. Regarding project types, road/highway and building projects are the most prominent, at 36.3% and 32.5%, respectively, followed by infrastructure (16.3%) and mixed projects (15.0%). The analysis emphasizes that road/highway and building projects are the most resource-intensive within public projects, where workflow inefficiencies and waste are common. The frequency analysis shows that the diverse and

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well-balanced group of professionals and project types provides a strong foundation for studying workflow challenges and assessing Lean Construction methods in publicly funded infrastructure projects in Visakhapatnam.

- **Descriptive Analysis**

Table 3: Descriptive Statistics

Question No:	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Q1	80	3	5	4.04	.675	-.029	.268	-.746	.531
Q2	80	2	5	3.96	.711	-.181	.268	-.375	.531
Q3	80	2	5	4.04	.675	-.283	.268	.083	.531
Q4	80	2	5	3.90	.773	-.162	.268	-.560	.531
Q5	80	2	5	3.96	.711	-.181	.268	-.375	.531
Q6	80	2	5	4.02	.738	-.214	.268	-.567	.531
Q7	80	2	5	4.08	.689	-.336	.268	-.018	.531
Q8	80	2	5	4.06	.634	-.345	.268	.665	.531
Q9	80	2	5	4.01	.675	-.253	.268	.039	.531
Q10	80	2	5	4.04	.729	-.441	.268	.136	.531
Q11	80	2	5	3.85	.689	-.291	.268	.201	.531
Q12	80	2	5	3.91	.704	-.080	.268	-.412	.531
Q13	80	2	5	3.85	.707	-.239	.268	-.006	.531
Q14	80	2	5	3.83	.683	-.027	.268	-.321	.531
Q15	80	3	5	3.75	.621	.205	.268	-.546	.531
Q16	80	3	5	4.07	.663	-.068	.268	-.668	.531
Q17	80	2	5	4.04	.795	-.510	.268	-.117	.531
Q18	80	3	5	4.13	.725	-.216	.268	-1.050	.531
Q19	80	2	5	4.02	.675	-.283	.268	.083	.531
Q20	80	3	5	4.01	.616	.000	.268	-.275	.531
Q21	80	2	5	3.86	.713	-.202	.268	-.102	.531
Q22	80	2	5	3.81	.719	.109	.268	-.631	.531
Q23	80	2	5	3.87	.769	-.294	.268	-.213	.531
Q24	80	2	5	3.78	.706	.106	.268	-.557	.531
Q25	80	2	5	3.91	.756	-.011	.268	-.817	.531
Q26	80	3	5	3.76	.684	.365	.268	-.826	.531
Q27	80	2	5	3.90	.660	-.177	.268	.058	.531
Q28	80	3	5	3.87	.663	.142	.268	-.696	.531
Q29	80	2	5	3.84	.742	.104	.268	-.771	.531
Q30	80	2	5	3.86	.713	.013	.268	-.546	.531
Q31	80	2	5	3.90	.750	-.040	.268	-.761	.531
Q32	80	2	5	3.87	.700	-.050	.268	-.411	.531
Q33	80	2	5	3.84	.725	-.128	.268	-.271	.531
Q34	80	2	5	3.91	.773	-.162	.268	-.561	.531
Q35	80	3	5	3.96	.729	.039	.268	-1.086	.531
Valid N	80								

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Descriptive analysis from the survey responses of (N=80) in Table 3 shows consistently high mean values across all 35 questions (M = 3.75–4.14), indicating that inefficiencies are systemic and deeply rooted in publicly funded projects. Workforce & Skills (M = 4.14) and Design & Documentation (M = 4.07) are identified as some of the most critical factors causing workflow inefficiencies. Most respondents strongly agree that workforce and skill shortages, design errors, and frequent design changes are the main sources of operational inefficiency and waste. Planning & Scheduling and Material Handling highlight systemic issues in coordination, communication, management timelines, and supply chain responsiveness, leading to delays and reduced productivity on construction sites. Therefore, these inefficiencies are not isolated but systemic, requiring targeted interventions to align operations and improve overall project performance. External and financial constraints, such as approval delays and low-bid contracting, were identified as major obstacles. Finally, the data analysis for Lean Practices (M = 3.83–3.97) highlights limited adoption of lean construction tools like Just-in-Time, 5S, and continuous improvement in construction workflow, which have proven to maximize value and minimize waste. Overall, the findings suggest that public construction projects follow a hierarchical chain of command, which remains a traditional approach. While lean construction principles are not fully implemented in publicly funded projects in Visakhapatnam.

- **Regression Analysis**

Table 4: Regression Analysis

Predictor	Coefficient (B)	Std. Error	t-value	p-value	Significance
Planning	0.143	0.119	1.196	0.236	ns
Design	**0.297**	0.123	2.414	**0.018**	☑ Significant
Coordination	0.152	0.123	1.234	0.221	ns
Workforce	0.044	0.124	0.352	0.726	ns
Materials	-0.032	0.111	-0.291	0.772	ns
External	-0.089	0.125	-0.709	0.481	ns

Table 4 indicates, a regression analysis was performed to explore the relationships among variables in public construction projects. The analysis shows that Design & Documentation is one of the most critical factors for implementing lean construction practices. This conclusion is based on a regression analysis indicating a statistically significant relationship, evidenced by ($\beta = 0.297$, $p < 0.05$). The results highlight a positive and measurable impact ($\beta = 0.297$). Therefore, improvements in design and documentation quality are key enablers for adopting lean practices. While other workflow areas, such as Planning and Coordination, were considered very important by participants, their effects were not statistically confirmed by the regression analysis. This suggests their influence on lean implementation might be indirect or mediated by a fundamental design flaw. As a result, the findings emphasize that any strategy or policy aimed at increasing efficiency in public construction should prioritize improving design management processes to create a supportive environment for lean methodology implementation.

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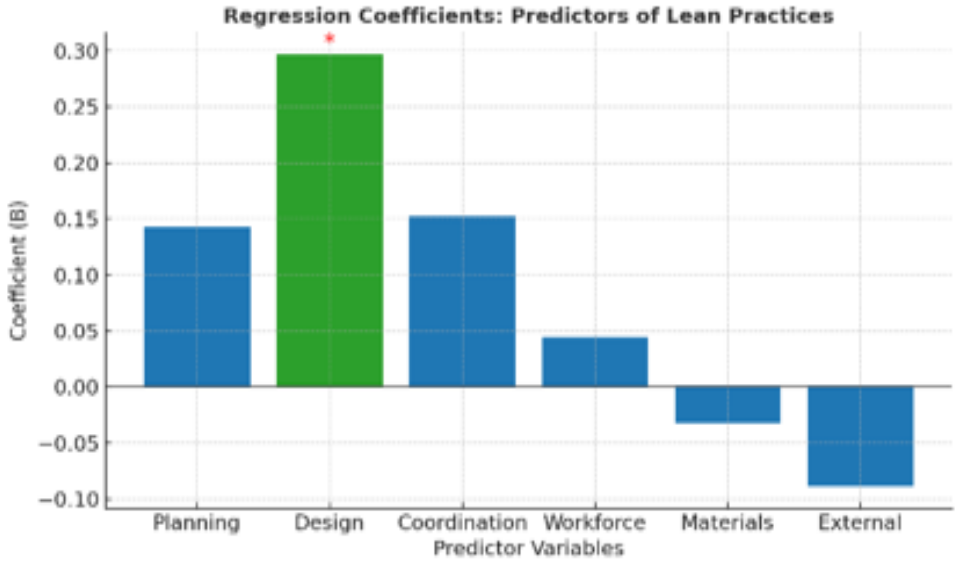

Figure 1: Regression Coefficient

Recommendations

Strengthen Design Management Practices

- Conduct a constructability review during the project preconstruction phase to identify potential clashes and optimize buildability.
- Early stakeholder engagement to enhance work procedure and avoid late-stage design.
- Implementing real-time documentation updates to improve coordination to reduce rework.

Workforce Training Enhancement and Standardization

- Applying lean construction tools and strategies to build operational discipline, such as 5S, Just-in-Time, and Kaizen.
- Standardize work protocols by creating a uniform procedure for task execution to reduce variability and ensure consistent task execution across teams.
- Introducing a program or procedure to manage worker fatigue and safety to mitigate delay, time loss, and material wastage due to employee mistakes as a result of fatigue.

Integrated Planning and Scheduling

- Adopt look-ahead planning and dynamic scheduling tools, such as the last planner system, to allow the organization to forecast potential workflow issues before they occur.

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- Synchronize design and construction schedules by regular meetings, setting clear deadlines, and a shared timeline to prevent idle time and miscoordination between trades like plumbing, electrical, etc.

Material Handling and Procurement Optimization

- Adopting digital tools for inventory tracking to prevent over-ordering and material waste.
- Schedule material deliveries to coincide with the site readiness.
- Implementing storage protocols to keep material safe and properly stored, and hold suppliers accountable.

Limitation

- Geographical context: The study is limited to Visakhapatnam, within the public infrastructure. The findings may not be generalized to the private sector and other regions.
- Target population size limitation: The sample provides a comprehensive information view, but may not capture all the stakeholders' perspectives.
- Data bias: Survey and interview participants are based on subjective perceptions, which may be affected by individual experiences, personal views, roles, or the culture of their organization.

CONCLUSION

The construction industry is recognized as the backbone of socio-economic development. Well-planned and efficiently executed infrastructure projects greatly influence growth by directly creating jobs, supporting regional development, and providing amenities that enhance the quality of life. However, the sector often faces inefficiencies and criticism for producing significant waste. The construction sector accounts for 30% of the world's waste annually, posing challenges to both economic sustainability and environmental health. Prior research has mainly focused on solid waste management, often neglecting workflow inefficiencies and their effect on waste production. Few studies have addressed inefficiencies in work procedures, which are the primary source of physical waste. This research aims to identify factors in construction workflow that impact operational inefficiency and waste generation in public projects across the Visakhapatnam district, Andhra Pradesh. In this study, a reliable survey instrument with a Cronbach's Alpha between 0.830 and 0.869 was used. Data from 80 participants, mostly operational stakeholders such as site engineers (33.8%) and contractors (31.3%), ensure that the results represent the views of professionals based on experience. The findings indicate that publicly funded projects encounter widespread operational challenges. While descriptive analysis highlighted key variables like Workforce & Skills and External & Financial factors, the multiple regression analysis offers more detailed insights. It shows that the design & documentation phase is the most influential factor for implementing lean

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construction practices ($\beta = 0.297$, $p < 0.05$). This suggests that common inefficiencies, such as design errors and frequent changes, are systemic issues that directly hinder the successful adoption of lean policies. The results also imply that other highly-rated factors may influence lean implementation indirectly or through underlying design problems. The study concludes that, despite awareness of operational challenges, the main barriers to improving efficiency in public projects stem from upstream design management. Successfully adopting lean construction requires shifting focus from operational symptoms to fixing systemic issues in design and documentation. Future research and policy efforts should prioritize enhancing design management as a critical factor to minimize waste through precise digital planning, encourage team collaboration to maximize value by centralizing information, improve work efficiency via optimized workflows and resource management, and ensure quality and safety through proactive approaches and early error detection. Additionally, optimizing planning and scheduling with pull-based lean principles, such as the LEARN (last planner commitment process, a lean construction-based principal software (Should, Can, Will, Did, Learn), can foster continuous improvement and enhance the industry's reputation.

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