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Investigating Factors Influencing Waste Generation in Public Construction Workflows: A Case Study of GVMC, Visakhapatnam, AP.

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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, alongside the ongoing trajectory towards liberalization of international trade, have driven a substantial increase in construction activity. Such development necessitates a massive 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.*

While extant research has primarily centered on physical waste management, limited studies have been conducted on the impact of workflow inefficiencies as the primary causes of waste generation in construction projects. This research addresses this gap by investigating the construction work procedure lifecycle within the predominant public construction sectors, GVMC, in Visakhapatnam, Andhra Pradesh, India. This study is grounded to explore the primary factors contributing to inefficiencies and waste generation across the span of various construction project work lifecycles by the triangulation method, including general project information, contractual frameworks, planning and scheduling methodologies, workflow and process management, waste management practices, communication and collaboration strategies, technological tools, safety protocols, quality control measures, and performance metrics.

Through a meticulous synthesis of project document analysis and semi-structured interviews with construction project managers as well as site visits, the study elucidates that systematic inefficiencies in project workflows critically influence physical waste production. The findings illuminate that establishing a well-structured, context-specific workflow in the project lifecycle is essential for optimizing construction work processes, mitigating waste generation, maximizing value, and elevating overall project efficiency performance in conformity with client mandates and sustainability goals..

Keywords: lean construction, last planner system, building information modeling, workflow optimization, maximization of value, and minimization of waste, construction technology

I. INTRODUCTION

1.1 Background

The construction industry is recognized worldwide as a crucial driver of development and progress, playing a vital role in shaping the environment and advancing society (Samli, 2011). Economic prosperity and social growth rely heavily on construction and infrastructure development (Tibaijuka, 2009). However, the industry is also criticized for being one of the largest sources of waste generation, which negatively affects both the economy and environmental sustainability.

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Visakhapatnam is one of the fastest-growing cities (Reddy, Anil, & Kumar, 2018), while construction waste is a significant concern due to rapid urban development. The rising demand for infrastructure often faces challenges because of the fragmented, disconnected, and complex nature of work procedures, rather than smooth, integrated processes. Effective management of construction workflows and the adoption of optimized, well-organized work processes have become crucial strategies to address these issues. The Lean Construction management philosophy, which emphasizes reducing waste and increasing value, highlights the importance of improved coordination, communication, and execution throughout the entire construction project lifecycle.

1.2 Study Area and Importance

Visakhapatnam is a rapidly growing urban area driven by its industrial, urban center, and economic significance in the Indian state of Andhra Pradesh. The harsh coastal climate significantly impacts construction projects, making waste management a key challenge. This requires a focus on optimized design, careful execution of structures or buildings, such as a lean construction process to reduce waste, increase value, improve efficiency, and enhance the durability and sustainability of buildings.

Vizag hosts a variety of public and private construction sectors. These organizations are involved in different infrastructure, urban, and metropolitan city development projects. Among these, one of the main government construction agencies is where most projects are managed, controlled, and overseen. Understanding the workflow practices of this industry and identifying the factors that cause waste generation is crucial, not only for community-level project impacts but also to support broader national goals for sustainable urban development.

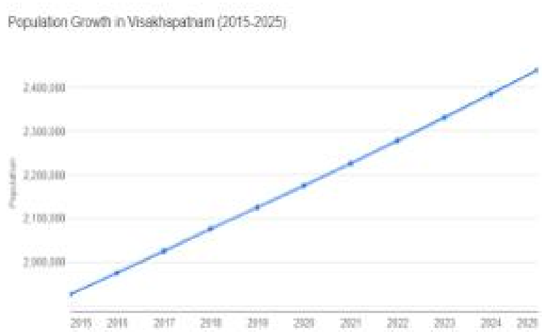

Figure 1 Population growth Vizag

Figure 2 study area

1.3 Research Problem

Despite technological advances in construction management, projects still face obstacles, such as delays, fragmented and discontinuous operational work processes, waste generation, communication gaps, and inefficient workflows. These issues hinder efficiency, value, objectivity, and project successful delivery. This study investigates the workflow efficiency of the GVMC, a public construction organization, to mitigate waste generation and aims to identify factors that cause inefficiency and waste generation within construction workflows and suggest practical improvements.

1.4 Research Objectives

This study aims to analyze factors contributing to inefficiency and waste generation within GVMC. Identify key factors that enable construction wastage.

To assess the construction workflow to encourage collaborative planning, early error detectability, waste reduction, and eliminate communication gaps.

To propose the best construction practices that can contribute to waste reduction and improved efficiency.

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1.5 Research Questions

What are the current workflow strategies and management process policies used by GVMC? Which project attributes contribute to waste generation in the construction workflow?

How does an efficient construction workflow, incorporating significant rules, policies, and new technology, impact efficiency and wastage?

What improvements can be made to maximize value and minimize waste to boost holistic workflow performance?

1.6 Scope and Limitations

The study aims to examine GVMC public construction organizations in Visakhapatnam. Data collection involved triangulation strategies, document reviews, semi-structured interviews with project managers, and field visits. The findings of this study are specific to the context and may not apply to other construction firms across India, but they offer valuable insights into public sector project management and construction waste reduction policies.

II. LITERATURE REVIEW

2.1 Construction Waste

Construction waste refers to any material, resources, or effort used that does not add value to the final product (Osmani, 2011). This includes material waste (excess inventory, defective materials, overproduction), resource waste (unnecessary movement, wasted energy, waste in capital/finance), and waste of effort (irrelevant motion, waiting, over-quality, defects/rework, unused talent/skills) (Manowong, 2012). Waste generation often results due to defective planning, changes in design & orders, procurement issues, poor coordination among stakeholders, and inefficient workflows (Nagapan et al., 2011). The impact of waste in construction is multi-dimensional, involving monetary losses, environmental impact, and inefficient resource use. India produces an estimated 150 million tons of construction and demolition (C&D) waste annually (BMPTC, 2020). Therefore, reducing waste at the construction process and workflow level is essential to achieving sustainability goals in projects.

2.2 Workflow and Process Management in Construction

Construction workflow is a systematic and strategic method for arranging, organizing, and sequencing tasks or activities professionally to ensure smooth and efficient project execution. It aims to remove ambiguity, mistakes, misunderstandings, errors, and waste. Workflow is a coordinated system of linked tasks and activities, including project specification, contract methods, planning and scheduling strategies, coordination, waste management, collaboration, technology adoption, safety protocols, quality assurance, and performance indicators. An effective workflow ensures efficient and timely haulage of materials and resources, reduces idle time, prevents rework, and thereby minimizes waste while maximizing value (Annika, 2024). Research studies' findings show that defective workflow causes bottlenecks, idle time, and material waste, time, effort, and resources (Mirriam Mophethe, 2024). Factors influencing construction workflow are project complexity, organization structure, policies, collaboration, goals, and objectives of the industry (Arashpour et al., 2015). While traditional construction processes are usually managed through a command-and-control approach, which lacks flexibility and often leads to reactive problem-solving instead of proactive planning (Gorod et al., 2018).

2.2.1 Project detail

Provides the fundamental information, such as project timeline, cost/duration, funding, location, and stakeholders' involvement. Understanding these fundamental critical factors enables precise scheduling and budgeting, ensures proactive and collaborative planning, enables faster decision-making, prevents over- ordering and damage to material from prolonged storage ultimately mitigates risks. A condensed or compacted schedule can lead to excess material and poor waste management (Ramadhan et al, 2025), where cost and duration influence project planning, budgeting, scheduling, project decision making, and meeting project objectives (Senapathy, 2024)

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2.2.2 Contract

A legal and administrative agreement between two or more entities (e.g., DBB, EPC, and PPP) defines the terms and conditions, including scope, payment terms, timelines, risk allocation, and dispute resolution approach, while outlining how construction work will be carried out according to the established procedure. Contract details are crucial in influencing construction waste generation. An effective type of contract and payment terms significantly affect waste reduction and efficient use of materials (Sawan et al, 2021). Study shows Change orders are a critical factor that directly causes rework and material waste (Sulistio et al, 2024). A clear risks clause with the project owner is a key driver for achieving sustainability goals and ensuring effective oversight (Wang et al, 2022).

2.2.3 Planning and Scheduling

Effective planning and scheduling in construction workflows promise smooth and successful project delivery within all project goals and objectives, and reduce delays and rework. Observational data show that the GVMC's operational framework remains rooted in conventional methods with limited integration of modern construction technologies. Traditional management tools, such as the Critical Path Method (CPM) and Gantt charts, are lacking in flexibility to handle unforeseen issues and real-time project execution. Cutting-edge project management software like Last Planner System with lean construction principles and BIM (Building Information Modelling) offers better insight into project timelines, enabling preemptive coordination and waste reduction (Hamzeh et al., 2015). These strategies align supply chains, facilitate streamlined workflow advance communication, thereby reducing idle time and mitigating operational errors.

2.2.4 Communication and Collaboration

Communication gaps or miscommunication are primary causes of waste and inefficiency in construction projects. Misunderstandings among the construction team can result in rework, incorrect installations, and scheduling issues (Love et al., 2004). Effective team collaboration and transparent information sharing can really help in preventing or reducing errors, ambiguity, and improving overall workflow. Technological tools like the last planner system, which is based on lean construction principles, and polices, have led to improvements in team coordination and collaboration in recent years. However, most public construction sectors still rely on paper-based communication and hierarchical reporting structures, which limit responsiveness and flexibility (Azhar et al., 2008).

2.2.5 Waste Management Practices

Waste in construction projects creates challenges for both economic viability and environmental sustainability. At the same time, defective workflow leads to excessive and often unprofessional use of natural resources.

The Indian public construction sector lacks systematic waste management and careful tracking. Public organizations such as GVMC in Visakhapatnam face the lack of formal waste audits or standardized waste management procedures and systematic waste tracking (Kumar N.S. 2015).

2.2.6 Performance Metrics

Construction performance is typically measured in terms of cost, time, and quality. However, these metrics do not fully capture process inefficiencies or project waste. Lean performance metrics such as workflow consistency, plan per cent complete (PPC), inventory turnover, and labor productivity present comprehensive insights into project health (González et al., 2008).

Implementing efficient and continuous improvement process to achieve a sustainable project, such as Kaizen, mandates organizations to apply feedback loops and learning mechanisms from past projects. Without following performance metrics approaches, it is difficult to detect bottlenecks or establish sustainable improvement. This dictates the need for project teams to implement project evaluation systems that evaluate direct and indirect factors that result in waste generation.

2.2.7 Summary

The literature reveals that waste generation in construction projects is a result of inefficiency in workflows. These inefficiencies are caused by contract issues, poor planning /scheduling, ineffective work coordination, lack of waste management strategies, inadequate use of technology adoption, safety measures, quality assurance, and lack of performance tracking. Lean Construction offers a robust framework and policies to address these challenges. This study contributes to this area by examining workflow and factors influencing inefficiency in construction projects and improvement opportunities in GVMC.

III. RESEARCH METHODOLOGY:

This study uses a comprehensive mixed-methods approach, including project document review, literature analysis, and interviews with the construction manager, site engineers, and stakeholders to identify factors influencing waste generation in public construction projects. The Greater Visakhapatnam Municipal Corporation (GVMC) was selected as a case study, with Visakhapatnam as the study area.

Data Collection:

Primary data was gathered through interviews, project document reviews, and site visits. Follow-up interview questions were developed for professionals, managers, and engineers. Secondary data were collected via an extensive literature review of existing sources such as books, journals, industry reports, and publications related to construction waste.

This study employs a qualitative and descriptive research approach, offering in-depth insights into current practices within GVMC. The organization was chosen because of its significant role in public

infrastructure and construction projects in the region. This selection offers a valuable empirical basis for analyzing different project types, sizes, and operational complexities, thereby increasing the relevance of the findings within the local context.

Analysis of Data: The data from five completed projects was collected, and an Excel sheet was used to analyze the data. The goal was to identify the root causes of significant construction waste by examining strengths, weaknesses, and potential workflow flaws.

IV. RESULT AND DISCUSSION

Project details

1) The construction of a 1000 KL ground-level storage reservoir with Pipelines & Pumping arrangements is located at Sai Ram Colony Hillock Zone II. This project aims to supply adequate and consistent water to the residents of the area with a budget of 3.50 Crores and a planned duration of 12 months, and team composition Chief Engineer, Superintending Engineer, Executive Engineer, Assistant Executive Engineer or Assistant Engineer, funded by AMRUT.

2) The construction of a 1000 KL Sump is a water storage and distribution system, aiming to improve the water supply shortage within the designated area. Where the goal is to enhance urban infrastructure and services. The project is located in the Section office Zone II, Yendada, Visakhapatnam, with a budget of 2.90 Cr and a duration of 12 months under the AMRUT funding scheme.

3) The construction of 2500 KL. Elevated level surface reservoir including pipelines also in Zone-II, Yendada, this is the largest project in size, cost, as well as duration, with a budget of 6.50 Crores and a duration of 24 months or two years.

4) The Replacement of a 400 mm dia asbestos cement pipe with a 400 mm dia ductile iron K9 Pipeline from the Sheela Nagar Pump house to the Jogivani Palem. The project is located in Zone V. It aims to replace and upgrade water transmissions to ensure a continuous, efficient, and reliable water supply to the area with a budget of 3.7 Crores and a shorter duration of 6 months. It is funded by the GVMC AMRUT scheme.

5) Replacement of 500 mm dia asbestos cement pipe with the ductile Iron K9 from Head Water Works to Wood Peta elevated level surface reservoir, located in Zone VII, Anakapali, with a budget of 3.30 Crores and a duration of 6 months, funded by AMRUT.

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Table 1project detail

Project Name	Cost/cr	Duration/Month	funding	Team composition
1000 KL GLSR & Pipeline	3.5	12	AMRUT	CE, SE, EE, AE
1000 KL pump	2.9	12	AMRUT	CE, SE, EE, AE,
2500 KL ELSR & pipeline	6.5	24	AMRUT	CE, SE, EE, AE
Replacement of 400 mm AC Pipeline	3.7	6	AMRUT	CE, SE, EE, AE
Replacement of 500 mm AC Pipeline	3.3	6	AMRUT	CE, SE, EE, AE

Planning and Scheduling

The data from the planning and scheduling table analyzes five public construction projects within GVMC, outlining the strategies and methodologies used by the organization in planning. It shows a mix of traditional and modern project management practices. While applying Gantt charts, CPM, and LOB (Line of Balance) works well for initial high-level planning, it is not agile enough for modern, complex projects that require frequent changes and continuous information flow. This makes scheduling and planning difficult when trying to identify constraints and interdependencies, leading to overemphasis and discontinuity. Based on lean principles, this term is considered muda (waste). Similarly, the use of Excel sheets as planning tools on most projects indicates ongoing reliance on a hybrid model not fully traditional or advanced—due to its basic functionality. Excel is preferred for small-scale projects, but in large-scale projects, it is limited by manual data entry, inefficiency, over-processing, and lack of coherent, integrated planning, which results in wasting time and resources instead of focusing on value-adding activities. Increasing the frequency of planning and scheduling meetings weekly, bi-weekly, or daily as needed could be helpful, but it reflects a system that attempts to fix issues after they occur rather than creating a smooth, continuous workflow to prevent problems at the start. This resembles a batch-and-queue system, often causing delays and inefficiencies rather than supporting a pull-based flow system. The variation in planning adherence highlights a significant gap between planned work and actual execution. This inconsistency indicates potential waste, as work is pushed through phases, creating bottlenecks such as waiting, rework, and unnecessary motion. A collaborative pull-based system could provide a more dependable workflow, ensure adherence to plans, and improve predictability, rather than relying on a milestone-based approach.

Table 2 planning & scheduling

Project	Planning tools	Scheduling method	Frequency	Planning adherence
1000 KL GLSR	Excel sheet	Gantt, CPM, LOB	Initial detail planning, regular meeting (weekly, bi-weekly, and Daily if needed), and ad-hoc meeting in case of a sudden issue.	Not aligned
1000 KL Pump	Excel sheet	Gantt, CPM, LOB	Initial detail planning, regular meeting (weekly, bi-weekly, and Daily if needed), and ad-hoc meeting in case of a sudden issue.	Partial aligned
2500 KL ELSR	Excel sheet	Gantt, CPM, LOB	Initial detail planning, regular meeting (weekly, bi-weekly, and Daily if needed), and ad-hoc meeting in case of a sudden issue.	Moderate aligned
400 mm DI K9 Pipeline	MS Project	Gantt, CPM, LOB	Initial detail planning, regular meeting (weekly, bi-weekly, and Daily if needed), and ad-hoc meeting in case of a sudden issue.	Fully aligned, meeting all the plan specifications
500 mm DI K9 Pipeline	Excel sheet	Gantt, CPM, LOB	Initial detail planning, regular meeting (weekly, bi-weekly, and Daily if needed), and ad-hoc meeting in case of a sudden issue.	Moderate aligned

Delay mitigation strategies:

The analysis of the following table indicates a reactive, traditional project management approach rather than a proactive workflow, as evidenced by the schedule variations, causes of delay, and mitigation methods. In this approach, corrective actions are taken after problems arise instead of preventing them in advance.

Conversely, a proactive workflow involves collaborative planning, early risk identification, and ongoing progress monitoring. When schedule variance data shows deviations and inconsistency, such as delays and lagging, it signals failure to establish a stable and predictable process. While delays caused by factors like rainfall, change orders, and communication issues are often external, they also reveal weaknesses in an inefficient, reactive system that wastes time and effort. These issues point to poor risk management and a fragmented information system unable to anticipate or resolve problems. Mitigation strategies, such as adding buffer time and using double-shift schedules, are mostly reactive—they address unforeseen delays with short-term fixes, which can lead to inefficiencies in planning, coordination, and workflow predictability.

Table 3 Delay Mitigation

Project	variance	delay causes	Mitigation
1000 KL GLSR	Deviation	Rainfall, site condition, change order, approval, and information flow issues.	Buffer time, contingency, resource adjustments, communication/coordination, double-shift work schedule
1000 KL Sump	Lagging	Rainfall, site condition, change order, approval, and information flow issues.	Buffer time, contingency, resource adjustments, communication/coordination, double-shift work schedule
2500 KL ELSR	Deviation	Rainfall, site condition, change order, approval, and information flow issues.	Buffer time, contingency, resource adjustments, communication/coordination, double-shift work schedule
400 mm DI K9 Pipeline	Minor deviation	Rainfall, site condition, change order, approval, and information flow issues.	Buffer time, contingency, resource adjustments, communication/coordination, double-shift work schedule
500 mm DI K9 Pipeline	Deviations from plan	Rainfall, site condition, change order, approval, and information flow issue.	Buffer time, contingency, resource adjustments, communication/coordination, double-shift work schedule

Waste Management Approach

The analysis of the waste management approach table provides insights into an organization's waste management strategies. Present a structured, consistent, and comprehensive approach, but a compensatory reactive framework to mitigate non-physical waste. The policy toward waste management demonstrates consistency and uniformity across all the projects, as idle time and rework lead to wasted resources and project delays, negatively affecting timelines and budgets. Process inefficiency causes delays and increases costs. While cost overruns threaten the credibility of the project budget. Material handling issues and design errors raise labor costs and affect project quality and stakeholder satisfaction. The mitigation approach adopts reduction strategies such as detailed scheduling, resource planning, clear communication, structured risk management, budget control, and Performance monitoring. While it enhances efficiency, improves collaboration and reduces waste.

The frequency of waste monitoring adheres to Construction and Demolition rules, along with the daily or weekly site supervision, progress and deviation reports submission to the department. However, the high frequency of waste racking, with daily, weekly, and possibly ad-hoc updates, shows a process that mostly relies on monitoring to find issues after they happen.

Table 4 Waste Management Strategies

Project	Type of waste tracked	Mitigation Approach	waste monitoring frequency
1000 KL GLSR	Idle time, inefficiency in process, cost, material, handling, and design error	Detailed Scheduling and Resource Planning, Clear Communication, Risk Management Framework, Budget, and Performance Monitoring	Adopting C&D rule, Weekly/daily progress reports, site supervisor, Weekly progress and deviation report, and schedule updates
1000 KL Sump	Idle time, inefficiency in process, cost, material, handling, and design error	Detailed Scheduling and Resource Planning, Clear Communication, Risk Management Framework, Budget Monitoring, Performance Monitoring	Adopting the C&D rule, Weekly/daily progress reports, and a site supervisor, potentially. Weekly progress and deviation report, and schedule updates
2500 KL ELSR	Idle time, inefficiency in process, cost, material, handling, and design error	Detailed Scheduling and Resource Planning, Clear Communication, Risk Management Framework, Budget Monitoring, Performance Monitoring	Adopting the C&D rule, Weekly/daily progress reports, and a site supervisor, potentially. Weekly progress and deviation report, and schedule updates
400 mm DI K9 Pipeline	Idle time, inefficiency in process, cost, material, handling, and design error	Detailed Scheduling and Resource Planning, Clear Communication, Risk Management Framework, Detailed Scheduling and Resource Planning,	Adopting the C&D rule, Weekly/daily progress reports, and a site supervisor, potentially. Weekly progress and deviation report, and schedule updates
500 mm DI K9 Pipeline	Idle time, inefficiency in process, cost, material, handling, and design error	Detailed Scheduling and Resource Planning, Clear Communication, Risk Management Framework, Budget Monitoring, Performance Monitoring	Adopting the C&D rule, Weekly/daily progress reports, and a site supervisor, potentially. Weekly progress and deviation report, and schedule updates

Collaboration and communication

The following collaboration table outlines GVMC collaboration strategies, highlighting a framework of a multi-modal approach that integrates a structured communication system with advanced digital tools. The model emphasizes regular interdepartmental meetings between the officials and stakeholders to ensure everyone remains informed about the project schedule and status, supported by email and SMS online digital information sharing to ensure consistent and timely departmental engagement with the site. Online Building Permission Management System (OBPMS) enables online access to building permits, while its function is to streamline and automate the process, allowing the application to interact and have access through the internet. GIS is an essential tool for GVMC, which is used in urban planning, management, and service delivery. The findings indicate a significant application of technology to track progress, facilitate progress, resolve conflicts, and ensure timely information flow. The organization is structured and designed in a way to function effectively within a conventional hierarchical top-down workflow. However, deep analysis of the approaches reveals the system follows a reactive conventional method, with potential flaws due lack of teamwork, shared value, and the presence of a top-down chain of command that could result in efficiency, delayed decision-making, and a communication gap, and follows a reactive rather than a proactive approach to problem-solving.

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Table 5 communication tools

Project	Communication	Tools	Effectiveness
All projects	Regular Interdepartmental meetings with officials and stakeholders. Scheduled inspections and review of plans, schedules, budgets, and change orders.	OBPMS cloud-based platform Dashboards, slake, mobile APP, Emails, or SMS, GIS: for visualizing and analyzing data related to projects. Project Management Software: to track progress, management of resources, and facilitate communication	Facilitates progress, addresses challenges, resolves conflicts Ensures timely information sharing. Streamlines the approval and inspection processes. Promote project monitoring, facilitate timely interventions, and bring accountability. In reactive mode.

Safety and quality

GVMC's safety and quality approach in public construction projects focuses primarily on compliance and follows procedures. Based on the data from the pipeline projects, GVMC ensures safety through standardized protocols such as PPE enforcement, addressing trench and excavation safety, electrical hazard mitigation, and site barricading. Quality assurance is conducted through post inspections and testing, including verifying RCC grade, running hydrostatic and pressure testing, pump calibration, and receiving oversight from regulatory bodies such as the Pollution Control Board. While these measures are reactive measures that reduce immediate risks after they happen, rather than proactive measures which prevent problems from happening, which is the LC approach can embed safety and quality throughout in execution phase. Therefore, by implementing the LC approach, which advocates collaborative planning, real-time and visual management for risk identification, and mistake-prevention techniques. Thus, GVMC could shift focus from inspection to prevention to reduce rework, enhance stakeholder engagement, and lead to efficient, resilient, and value-driven infrastructure.

Table 6 safety & quality approach

Project Name	Scope & Description	Safety Measures	Quality Assurance
1000 KL GLSR & Pipeline	Construction of the Reservoir and pipelines	Excavation safety protocols. PPE enforcement. Barricading and signage.	RCC grade testing. Pipeline pressure testing SCADA integration for monitoring
1000 KL Pump Installation	high-capacity pump for water distribution	Electrical hazard mitigation Fire safety systems Confined space entry protocols	Pump calibration. Flow meter testing. Compliance with IS standards.
2500 KL ELSR & Pipeline	Elevated Level Reservoir with distribution network	Crane operation safety Structural safety audits Fall protection systems	Load testing. Concrete strength verification. Third-party inspection
Replacement of 400 mm AC Pipeline	Replacement of asbestos cement pipeline with DI pipeline	Trench safety protocols Dust suppression Traffic diversion planning	Leak detection audits Pipe joint integrity testing GIS-based mapping
Replacement of 500 mm AC Pipeline	Upgrade of existing pipeline to improve water flow and reduce health risks	Worker health monitoring. PPE enforcement. Hazardous material handling protocols.	Hydrostatic testing Material certification. Pollution Control. Board oversight

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Performance metrics:

GVMC evaluates public project performance using traditional benchmark metrics such as schedule compliance, budget utilization, material adherence, safety inspection, environmental assessment, and feedback from citizens using project management tools such as Gantt charts, financial review, RCC and hydrostatic tests, and online complaint portals. These approaches are effective but it is a regulatory compliance-based and based on reactive inspection. While LC principles is a proactive encourages collaboration and emphasizing on continuous improvement and value delivery. The Time and cost metrics can optimized by Last Planner System and Target Value Design, quality would be embedded Poke Yak system and real-time feedback loops, safety is reinforced via daily huddles and visual controls, and stakeholder satisfaction is achieved through open communication and collaborative . This strategic transformation minimize operation waste improve reliability, and inline the GVMC's infrastructure practice with global best practices methodology.

Table 7 PPC

Metric Category	Performance Indicators Used by GVMC	Monitoring Tools & Methods	Projects
Time Management	Planned vs. actual completion dates Milestone tracking	Gantt charts Weekly progress reports Contractor review meetings	ELSR construction, and pipeline replacement
Cost Control	Budget utilization rate Cost variance analysis	Monthly financial audits Tender-based cost benchmarking Third-party cost validation	water supply projects and pump installations
Quality Assurance	Material compliance rate Number of defects per inspection Rework frequency	RCC grade testing Hydrostatic pressure tests Third-party inspections	GLSR/ELSR projects and pipeline
Safety Performance	Number of incidents reported PPE compliance rate Site audit scores	Daily safety checklists Incident logs Health & Safety Officer reports	excavation, trenching, and elevated works
Environmental Compliance	-Waste disposal compliance Water quality test frequency Pollution Control Board certification	daily water tests Monthly PCB inspections GIS-based waste tracking	pipeline replacement and water treatment projects

V. CONCLUSION

This study aims to examine inefficiencies in public construction workflows managed by the Greater Visakhapatnam Municipal Corporation (GVMC), focusing on identifying systemic factors that influence waste generation and inefficiency. The analysis shows that GVMC's current practices are based on a regulatory-driven framework centered on compliance- oriented protocols. Contracts are awarded through competitive bidding under AP Procurement Rules and ADB guidelines, and planning is conducted using milestone-based Gantt charts and contractor-submitted schedules. While these mechanisms ensure regulatory compliance, they often operate in silos, which limits adaptability and cross-functional coordination. Waste is generation resulted by fragmented communication across departments, reactive safety enforcement, redundant inspection cycles, and underutilized stakeholder feedback mechanisms. Collaboration occurs through site-level review meetings and digital portals but lacks continuous engagement and transparency needed for dynamic problem-solving. Safety and quality are enforced via PPE mandates, RCC grade testing, hydrostatic pressure audits, and third-party inspections, but these focus more on inspections rather than prevention. Performance metrics covering time, cost, quality, environmental compliance, and citizen satisfaction are tracked using progress reports, audit logs, and surveys; however, they are rarely integrated into real-time decision-making frameworks.

To address these inefficiencies, the study proposes adopting Lean Construction (LC) principles as a transformative strategy. Lean methodologies such as the Last Planner System, Target Value Design, built-in quality, and visual management offer a proactive, value-driven alternative to GVMC's current execution model. By embedding continuous improvement, collaborative planning, and stakeholder co-creation into workflows, GVMC can reduce material and process waste, improve schedule reliability, and enhance infrastructure delivery outcomes. The findings highlight the potential of Lean Construction not only as a technical solution but also as a cultural shift reorienting GVMC's public works from a compliance- based approach to a performance-driven, sustainable urban development.

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