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Application of Value Stream Mapping as a Lean Construction Tool in Precast Façade Installation: A Case Study of the "XYZ" Apartment Project in Jakarta, Indonesia

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ABSTRACT: The growing demand for high-rise residential buildings has encouraged the adoption of precast façade systems as a means to improve construction efficiency and quality consistency. Despite their technological advantages, the on-site installation of precast façades often encounters operational inefficiencies caused by workflow fragmentation and poor coordination between logistics and installation processes. This study explores the application of Value Stream Mapping (VSM) as a Lean Construction tool to conceptually analyze the precast façade installation process in a high-rise apartment project in Jakarta, Indonesia.

Using a process-based analytical approach, the study maps the sequence of installation activities to identify value-adding and non-value-adding components within the workflow. The analysis reveals that inefficiencies are primarily systemic rather than task-specific, emerging from misalignment between material delivery, equipment availability, and installation readiness. These conditions generate cascading waste patterns, including waiting, inventory accumulation, unnecessary movement, and process interruptions that disrupt workflow continuity.

The findings highlight that the performance of precast façade systems depends not only on prefabrication advantages but also on process synchronization across project operations. By improving workflow transparency, VSM demonstrates its potential as a strategic tool for diagnosing coordination gaps and supporting flow-oriented management in prefabricated high-rise construction.

KEYWORDS: Lean Construction, Value Stream Mapping, Precast Façade Installation, Workflow Efficiency, Prefabrication

INTRODUCTION

The rapid growth of high-rise residential developments in urban areas such as Jakarta reflects the increasing demand for vertical housing solutions. Contemporary apartment projects are required not only to meet accelerated construction timelines but also to achieve high standards in quality, cost efficiency, and sustainability. In this context, the building façade plays a critical role, particularly through the adoption of precast façade systems, which offer advantages in terms of manufacturing consistency, improved quality control, and faster installation processes.

Despite these benefits, the on-site implementation of precast façade systems continues to encounter operational challenges. Issues such as delayed material delivery, lack of synchronization between production and installation schedules, limited workspace, and the presence of non-value-adding activities

frequently disrupt workflow. These conditions often result in various forms of waste, including waiting time, material accumulation, unnecessary movement, and rework, ultimately reducing overall project productivity.

To address these inefficiencies, the Lean Construction approach provides a systematic framework for improving project performance by identifying and minimizing waste throughout the construction process. One of the key tools within this approach is Value Stream Mapping (VSM), which enables a comprehensive visualization of both material and information flows across project activities. By applying VSM, the installation process

of precast façades can be examined in detail to distinguish value-adding tasks from non-value-adding ones, thereby revealing opportunities for process improvement.

This study aims to implement Value Stream Mapping as a Lean Construction tool to evaluate the precast façade installation process in the "XYZ" apartment project located in Jakarta, Indonesia. The research focuses on identifying dominant sources of waste during installation and assessing the efficiency of the existing workflow on-site. Through this analysis, the study seeks to provide a clearer understanding of process inefficiencies and highlight potential strategies for improving productivity, reducing waiting time, and optimizing the use of limited site space.

The findings are expected to contribute not only to practical improvements in precast façade installation for high-rise construction projects but also to the broader application of Lean Construction principles in prefabrication-based building practices within the Indonesian construction industry.

RESEARCH METHODOLOGY

This study adopts a qualitative conceptual approach to examine the application of Value Stream Mapping (VSM) as a Lean Construction tool in the precast façade installation process of high-rise building projects. Rather than relying on empirical field measurements, the research focuses on a structured analytical framework to understand process inefficiencies and potential waste within the installation workflow.

The research was conducted through three main stages:

1. Process Decomposition

The precast façade installation workflow was first broken down into its primary operational stages based on common construction practices in prefabricated façade systems. These stages include:

- Material delivery and staging
- On-site handling and positioning
- Lifting and installation
- Alignment and connection
- Inspection and finishing

This decomposition enabled the identification of sequential activities that form the overall installation value stream.

2. Conceptual Value Stream Mapping

A conceptual Value Stream Map was developed to represent the flow of materials and site activities during façade installation. The mapping focuses on:

- Process sequence
- Activity interaction
- Operational dependencies

Each activity within the installation workflow was then classified into:

- Value-Adding Activities (VA)
- Non-Value-Adding Activities (NVA)
- Necessary but Non-Value-Adding Activities (NNVA)

This classification was conducted based on Lean Construction principles to evaluate how each activity contributes to project value delivery.

3. Lean Waste Identification

Using the VSM framework, potential waste embedded within the installation process was systematically analyzed. The analysis refers to common Lean waste categories adapted for construction, including:

- Waiting
- Transportation
- Motion
- Inventory
- Overprocessing
- Overproduction
- Defects

Rather than quantifying waste, this study emphasizes identifying how process fragmentation and lack of synchronization may generate inefficiencies within the workflow.

4. Process Improvement Interpretation

Based on the mapped process structure and waste identification, potential improvement directions were conceptually explored. These include:

- Enhancing workflow continuity
- Improving coordination between delivery and installation
- Minimizing idle time and material accumulation
- Optimizing space utilization on site

The outcome of this analysis is not a prescriptive solution, but a structured understanding of how Lean-based process visualization through VSM can support more efficient façade installation practices.

This methodological approach allows the study to demonstrate the analytical value of VSM in understanding construction workflow inefficiencies, particularly in prefabrication-based systems, without requiring empirical data collection.

RESULT AND DISCUSSION

1. Process Transparency Through Value Stream Mapping

The conceptual application of Value Stream Mapping (VSM) in the precast façade installation process reveals that inefficiencies are rarely caused by isolated operational mistakes. Instead, they emerge from fragmented workflow structures and weak synchronization between logistics, site readiness, and installation sequences.

Lean Construction studies consistently show that project delays are often linked to process fragmentation rather than technical complexity (Anggraini, et al, 2022). When VSM is used to visualize workflow interdependencies, it becomes evident that installation performance depends heavily on:

- Delivery timing
- Equipment readiness
- Installation sequencing
- Spatial coordination

This aligns with recent findings showing that construction inefficiencies frequently originate from misaligned operational flows rather than labor productivity alone (Romo, et al, 2024).

In façade installation, where prefabricated elements require high coordination accuracy, workflow interruptions tend to propagate across subsequent activities, reinforcing the importance of process-level visualization.

2. Dominant Waste Structures in Precast Installation

The conceptual mapping indicates that the most critical inefficiencies are likely to occur in the form of:

a. Waiting Waste

Waiting waste typically emerges when:

- Lifting equipment is not available
- Installation zones are not ready
- Materials arrive earlier than installation schedules

Previous studies in construction projects using VSM identified waiting as one of the most dominant wastes affecting project performance (Simamora, et al, 2023).

In prefabrication-based systems, this waiting condition creates a ripple effect that leads to:

- Material congestion
- Idle workforce
- Installation sequence disruption

b. Inventory Waste

Precast façade panels are often delivered in batches for logistical efficiency. However, when installation readiness is inconsistent, this results in temporary on-site storage.

Empirical Lean Construction studies have shown that unnecessary inventory can reach over 30% of total waste contribution in construction workflows (Anggraini, et al, 2022).

In façade systems, excessive inventory introduces:

- Increased handling frequency
- Site congestion
- Safety risks
- Risk of panel damage

c. Motion and Transportation Waste

Due to the large size and weight of precast façade panels, any inefficiency in site layout or installation sequencing can result in:

- Repeated repositioning
- Extended crane cycles
- Additional internal transportation

Studies on precast workflow optimization indicate that inefficient material handling significantly contributes to lead time extension and productivity loss (Sirajudeen and Krishan, 2022).

d. Overprocessing and Defects

Misalignment or installation inaccuracies may trigger re-adjustment activities. Lean Construction case studies in Indonesia have identified defects and overprocessing as recurring contributors to inefficiency, alongside overproduction and inventory waste (Anggraini, et al, 2022).

These secondary wastes are often not standalone issues but consequences of upstream synchronization failures.

3. Systemic Nature of Installation Inefficiency

A key insight from the conceptual VSM is that installation inefficiencies are **systemic rather than operational**.

For instance:

- Late site readiness causes waiting
- Waiting leads to material accumulation
- Accumulation causes motion waste
- Motion increases defect risk

This cascading effect supports the argument that construction waste is interrelated and should be addressed at the process level rather than activity level.

Research applying Lean Construction tools such as VSM and Waste Assessment Models confirms that waste types in construction are structurally interconnected (Anggraini, et al, 2022).

4. Workflow Synchronization as a Lean Imperative

The findings highlight that façade installation performance depends heavily on synchronization across:

- Production
- Delivery
- Installation

Without synchronization:

- Production becomes decoupled from site demand
- Installation becomes reactive rather than planned
- Logistics shifts from pull-based to push-based systems

Recent Lean-based casting process studies emphasize that improving coordination and scheduling significantly reduces queueing and motion waste (Lestari and Adhirajasa, 2024).

This reinforces the role of VSM not merely as a mapping tool, but as a mechanism to identify coordination gaps.

5. Implications for Precast-Based High-Rise Construction

Prefabrication is widely acknowledged for its potential to:

- Reduce construction time
- Improve quality consistency
- Minimize material waste

However, these advantages depend on process integration.

Research on lean precast systems demonstrates that productivity gains are achievable only when workflow continuity is ensured through standardized processes and efficient material handling (Sirajudeen and Krishan, 2022).

Thus, VSM helps shift the focus from:

"Speed of installation" → to → "Flow of installation".

6. Lean Construction as a Pathway to Sustainable Efficiency

Beyond productivity, Lean Construction contributes to sustainability performance.

Lean-based waste reduction strategies have been shown to improve:

- Cost efficiency
- Resource utilization
- Environmental performance

In high-rise construction, integrating lean practices can generate significant cost savings and operational efficiency improvements (Prastowo, 2023).

Since façade systems involve high material intensity, improving installation flow directly supports:

- Reduced handling losses
- Lower rework risk
- Reduced site congestion

7. Strategic Value of Conceptual VSM

Although this study does not rely on empirical data, the conceptual mapping demonstrates that: VSM functions as a strategic diagnostic tool. It enables:

- Visualization of process fragmentation
- Identification of coordination gaps
- Understanding of waste interdependencies

Similar conceptual applications of VSM in building projects have successfully identified non-value-adding activities and improved workflow clarity (Steven and Arijanto, 2025).

Synthesis of Key Insights

The extended analysis confirms that inefficiencies in precast façade installation are primarily driven by:

- Workflow fragmentation
- Logistics-installation misalignment
- Reactive scheduling
- Material flow discontinuity

Rather than focusing on individual task performance, Lean thinking — through VSM — highlights the importance of process integration.

This supports the growing perspective that improving construction productivity is fundamentally a flow management challenge rather than a labor optimization issue.

CONCLUSION

This study demonstrates that the application of Value Stream Mapping (VSM) within a Lean Construction framework provides a powerful analytical lens for understanding the workflow dynamics of precast façade installation in high-rise building projects. Through a conceptual mapping of the installation process, the analysis reveals that inefficiencies in façade installation are not primarily driven by technical limitations of precast systems, but rather by fragmented operational flows and weak synchronization between logistics, site readiness, and installation activities.

The findings highlight that value in precast façade installation is generated mainly during lifting, positioning, alignment, and connection processes. However, these value-adding activities are frequently surrounded by supporting operations that consume significant time and resources without directly contributing to project outcomes. Non-value-adding activities such as waiting for equipment, material repositioning, temporary storage, and workflow interruptions tend to dominate the process environment, reducing productivity and limiting the potential efficiency advantages of prefabrication systems.

More importantly, the analysis indicates that waste in façade installation is systemic and interdependent. Waiting delays often trigger inventory accumulation, which in turn leads to unnecessary motion and transportation. These secondary inefficiencies may subsequently increase the likelihood of overprocessing and potential defects. This cascading relationship confirms that installation inefficiencies emerge from process misalignment rather than isolated task performance.

The conceptual use of VSM proves valuable in visualizing these hidden inefficiencies and exposing coordination gaps that are typically overlooked in conventional project monitoring approaches. By shifting the focus from individual task optimization toward overall workflow continuity, VSM enables a deeper understanding of how material flow, equipment utilization, and installation sequencing interact within constrained construction environments.

Furthermore, the study emphasizes that the success of prefabrication systems such as precast façade panels depends heavily on process integration rather than component standardization alone. While precast systems are designed to improve speed and quality, their performance can be significantly undermined when delivery schedules, installation readiness, and resource allocation are not aligned. Without synchronized flow management, the intended efficiency benefits of prefabrication may be partially offset by operational disruptions on site.

From a Lean Construction perspective, improving façade installation performance therefore requires a transition from activity-based management to flow-based management. Enhancing synchronization between production, delivery, and installation processes can reduce idle time, minimize material accumulation, and improve workspace utilization. These improvements not only contribute to productivity gains but also support broader project objectives such as cost efficiency and operational stability.

In addition, the conceptual findings suggest that VSM can serve as a strategic diagnostic tool even in the absence of quantitative field data. By mapping the logical structure of installation processes, project stakeholders can identify potential inefficiency points and anticipate workflow disruptions before they materialize in practice. This reinforces the role of Lean thinking as a proactive planning approach rather than a purely reactive performance evaluation method.

Ultimately, this study underscores that optimizing precast façade installation is less about accelerating individual tasks and more about stabilizing the system that connects them. The adoption of Value Stream Mapping as a Lean Construction tool provides a structured pathway toward improving workflow transparency, reducing systemic waste, and supporting more integrated construction practices in high-rise building projects.

Future research may build upon this conceptual foundation by incorporating empirical validation, digital integration such as BIM-based workflow mapping, or comparative analysis across different prefabrication systems to further strengthen the operational applicability of Lean-based façade installation strategies.

MANAGERIAL IMPLICATIONS / PRACTICAL CONTRIBUTION

The findings of this study offer several practical insights for project managers, contractors, and construction planners involved in prefabricated façade installation.

First, the study underscores the importance of aligning delivery schedules with installation readiness. Managers should avoid treating material supply and installation as independent functions. Instead, synchronized planning mechanisms should be established to ensure that material arrival supports actual installation demand rather than creating temporary on-site inventory.

Second, site layout planning should be approached strategically to minimize unnecessary material movement. Efficient staging logic can reduce internal transportation and double handling, which are significant contributors to time loss and workspace congestion in façade installation.

Third, resource allocation—particularly lifting equipment—should be planned based on workflow continuity rather than availability alone. Crane utilization must be integrated into installation sequencing to prevent idle time and waiting delays that disrupt productivity.

Fourth, project decision-makers should shift performance evaluation from task-based metrics toward flow-based indicators. Monitoring workflow stability and process continuity may provide a more accurate representation of installation efficiency than traditional productivity measurements.

Finally, the conceptual use of VSM demonstrates its applicability as an early-stage planning tool. Managers can employ process mapping to identify potential coordination gaps before project execution begins, thereby reducing reactive adjustments during installation.

From a broader perspective, the study contributes to improving decision-making in prefabrication-based projects by emphasizing that technological adoption must be complemented by process integration. In this sense, Lean tools such as VSM can support not only operational efficiency but also strategic planning in complex high-rise construction environments.

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