

# Exploring Lean Construction for Housing Projects: A Literature Review

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## Exploring Lean Construction for Housing Projects: A Literature Review

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**Abstract.** One of the problems that often arise in housing projects is time delay, which may result in an increase in construction costs. This delay can be attributed to deficiencies in site management, ineffective communication strategies, and a lack of coordination between stakeholders. Lean construction is a method that can be used to improve the construction management system. The basic concept of this method is to reduce activities that do not add value and increase the value. The purpose of this study is to explore the implementation of lean construction principles at housing projects in order to improve project management so that delays can be minimized. The objectives of this research are; (1) to identify waste in the construction process, (2) to find barriers in applying lean construction principles, and (3) to recommend strategies for implementing lean construction principles in housing projects. A comprehensive literature review is conducted to achieve the aims and objectives of this study. The results show that the implementation of lean construction principles in housing projects can provide several benefits, such as minimizing waste, reducing construction time, improving building quality, and providing better benefits to contractors.

**Keywords:** delay, waste, lean construction, housing projects

### 1. Introduction

Construction is a complex industry, where each project has its own peculiarities and there are many uncertainties. The success of construction projects is generally based on the accuracy of the time and cost of the contracts and customer satisfaction. For this reason, many researchers are studying the causes and factors that cause project delays, but most of these studies rarely discuss about housing projects [1].

The housing construction projects is unavoidable from the problem of time overrun, which indicates a delay in construction projects. Delays will result in several issues i.e. inflated prices, disputes between house owners and contractors resulting in arbitration, loss of productivity and revenue, and contract termination [2]. In Indonesia, from the various types of waste variables that exist, delays are the most significant form of waste and must be the main concern of the contractors to improve their management capabilities [3]. Poor project management is the main reason for delays in construction projects, therefore problems related to management need to be understood and sought the most efficient method to find a solution [4].

Improving project management will minimize the waste that occurs during the construction process, thus reducing project delays. One of the most effective methods for improving project management and reducing waste is the implementation of lean principles in the construction industry,



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known as Lean Construction. Implementation of Lean Construction practices includes culture, plans, tools, and ideas to maximize value whereas minimizing all varieties of waste [5]. This method does not only limited to the construction process, but also product development, relationship between suppliers, strategic management, and human management. This is used to meet the demands of customers who are increasingly demanding quality products, better performance, and lower costs [6]. This research aims to evaluate waste activities that cause delays in the construction process based on literature studies. Then identify barriers to implementing the lean construction method based on previous research, subsequently recommend strategies for implementing the lean construction method in the housing project.

## 2. Method

A literature survey has been conducted on quantitative and qualitative empirical studies published in several international journals such as journal of civil engineering and technology, journal of technology and management, journal of productivity and performance management, lean construction journal, and others journal. Paper traced by using a few key word such “lean construction”, “project management”, “housing construction”, “waste management”, and “waste in construction” in the publisher websites like ScienceDirect, Emerald Insight, Lean Construction Institute Journal, Elsevier, and other publisher.

## 3. Results and Discussion

### 3.1 The Origin of Lean Construction

The term “lean” has been known since 1900 when the manufacturing industry was developing, then in 1950 the Toyota research team, led by Taichi Ohno, created a method called Toyota Production System or Lean Production that focused on reducing waste and increasing value [7]. The goal of lean production is to optimize the performance of production system to meet varied and unique customer needs [8]. Principles in lean production that utilize smaller human resources, less area, while changing existing operations and gaining large improvements in quality, productivity, and others have attracted the attention of construction practitioners [9].

Construction practitioners and researchers since the 1990's have analyzed the possibility of implementing lean production principles in the construction. The International Group for Lean Construction (IGLC) has an important contribution in making the basis of lean construction, by taking the core of lean production principles and apply these principles to the construction management process [10]. [11] The implementation of lean production in the construction industry and interpreted a production management paradigm in three points of view namely as transformation, flow, and value. The main principles of these three things are making the production process more efficient, minimizing waste (non-value-adding activities), and getting the best possible value to reduce value loss [12]. These three complementary ways ultimately create a lean construction concept [8]. Lean construction is a concept used in manufacturing production and operations management which focuses primarily on continuous improvements in production processes to eliminate redundancies from the value chain leading to better delivery of finished goods that offer more value to the end customer [13].

### 3.2 Lean Construction Principles

[11] The eleven principles of the lean construction and described them as being principles for flow process design and improvement. The whole principles are interrelated and ultimately create added value to the products produced. The eleven principles will be explained in the following sections.

#### 3.2.1 Reduce the Share of Non-Value Adding Activities

The cause of the emergence of activities that do not provide added value is due to the design of the organizational structure, ignorance, and the nature inherent in the production process itself. Some examples of activities that do not provide added value are rework, waiting, and workplace accidents

[14]. Reducing as much as possible these activities has a positive impact on productive flows and minimizing costs [6].

### 3.2.2 Increase Output Value Through Systematic Consideration of Customer Requirements

Implementation of this principle is by defining customer needs at each stage of production. By defining these requirements of each customer, the value of the product will be maximal, but many companies fail to apply this principle because they are too focused on reducing costs at each stage of production [14].

### 3.2.3 Reduce Variability

Very varied production processes often interfere with productivity of a project, prefabrication is widely recognized to reduce variation in the construction process. In addition, standardization of processes is needed to minimize negative aspects of variability and ensure the process flow runs smoothly [6, 14].

### 3.2.4 Reduce Cycle Time

Cycle time is the time needed in one production process from start to finish. [11] Cycle time is the sum of process time, inspection time, waiting time, and time to move. By pressing the cycle time to be almost the same as the processing time, it will have a beneficial impact on cost, time, and quality [6].

### 3.2.5 Simplify by Minimizing the Number of Steps and Parts

A complex product or production process will have a direct impact on its production costs, besides the quality of the product is also less reliable. In this principle, simplifying means eliminating activities that are not valuable from a process and then redesigning the stages and parts of production to provide added value [6].

### 3.2.6 Increase Output Flexibility

Increasing the expertise of employees, making adjustments in each production process, modularizing product design, minimizing lot sizes to fit demand, reducing difficulty in setups and changeovers, are some of the approaches that can increase output flexibility [6, 13].

### 3.2.7 Increase Process Transparency

This concept can be implemented in every process in the company so that it can run thoroughly and be seen by every worker. Processes that are not transparent can lead to a tendency to err, it is difficult to find fault and reduce motivation for continuous improvement. Visual management is an example in applying this principle [11].

### 3.2.8 Focus Control on the Complete Process

Controlling the entire process with focus can avoid confusion when the production flow crosses different work units in the organizational structure, thus each worker can understand the responsibilities of their work. Collaboration with suppliers must be optimized to facilitate production flow between companies [6].

### 3.2.9 Build Continuous Improvement into Process

Activities that reduce waste and increase value continuously are important in the lean thinking philosophy. There are several methods that can be used to encourage companies to make continuous improvements such as measuring and monitoring the increase in work targets, increasing responsibility for each worker, standardizing and resolving problems from their roots [6].



#### 3.2.10 Balance Flow Improvement with Conversion Improvement

Conversion in this principle is related to the investment of new technology, equipment and others related to the production process. Before making a decision to convert, it is necessary to analyze and optimize the work flow first. The optimal work flow will require less investment if conversion is carried out [6].

#### 3.2.11 Benchmark

This principle means that a company must have a role model from other companies that can be a trigger to improve company performance. The steps in benchmarking are knowing the company's own processes and understanding the strengths and weaknesses of the process, then learning how they can become successful companies and then applying the knowledge to our company [6].

### 3.3 Waste in the Construction Process

Construction waste is assumed as residual material or tools that are not used after construction is completed, but every activity in construction that raise costs but do not provide added value either directly or indirectly is also a waste [15]. The following will explain the seven waste classification in the construction process.

#### 3.3.1 Waste From Overproduction (Unnecessary Work)

This waste is caused by producing earlier or more than is needed, thus requiring more storage, workers, and additional costs. In addition, this waste will also cause the material become damaged because it is stored too long [16].

#### 3.3.2 Waste From Rejects (Defects/Unsatisfactory Work)

This waste is caused by producing earlier or more than is needed, thus requiring more storage, workers, and additional costs. In addition, this waste will also cause the material become damaged because it is stored too long [16]. Some of the reasons that cause defects are due to poor design and specifications, lack of planning and supervision, poor teamwork, and lack of coordination between planners and workers [17].

#### 3.3.3 Waste in Transportation (Material Movement)

In the construction process, there are people and materials moving from one location to another for several stages. This transportation is related to the internal movement of material, where the lack of process flow will create many stops in the production cycle [8]. Excessive handling, inadequate use of equipment or poor road conditions can also cause this type of waste.

#### 3.3.4 Waste in Processing (Over Processing)

Waste in over processing is described as extra processing from work beyond client requirements [8]. This also includes a lack of utilization of creativity, skills, and knowledge from employees [10].

#### 3.3.5 Waste From Inventory

Companies often order material more than needed to cover for defects in materials on-site, or in anticipation if the material is late in delivery [5]. However, material stored in the inventory often cannot be used because of deterioration, vandalism, or even stolen [8].

#### 3.3.6 Waste From Waiting (Delays)

Waste from waiting is expounded to turn-around time or cycle time of any method within the project such as waiting for material, searching for information and tools among others [5]. When workers delay their work because they are waiting for the next processing step, time is wasted, therefore production flow must be continuous and smooth [6].

### 3.3.7 Waste From Movement (Motion)

Waste of motion arises from every movement of resources both human and equipment that is not needed for the successful completion of a process. This may be caused by inadequate equipment, ineffective work methods, or poor workplace arrangements [8].

### 3.4 Delay Factors in Housing Construction

Delay in the construction industry is often caused by various factors, such as late payment of contractors or suppliers, price fluctuations, increase in material prices, insufficient funding from clients, varied demand, and insufficient capital. The effect of these delays can lead to cost overrun, time overrun, no continuation work with the client, and problems in court / arbitration [18].

[1] The factors of delay in housing projects into six parts, namely inefficient project management, poor owner/client management and competence, regulation, poor project clarity, finance, and exogenous conditions. The application of these factors can be seen in the following table.

**Table 1.** Application of delay factors in a housing project

Description/factor name	Example
Inefficient project management	Poor management and supervision, poor communication and coordination, inexperienced planning teams, complicated projects, design errors, delays in material shipments, unrealistic planning schedules, misunderstandings between owners and engineering planners.
Poor owner/client management and competence	Owner slow decision making, late in approval documents, poor communication and coordination with other parties, unrealistic duration of contract, owner lacking experience in construction projects.
Regulation	Delay in obtaining work permits from the government, delays in the provision of utilities (water and electricity), delays in inspections, changes in government laws and regulations.
Poor project clarity	Change orders / design by owners during construction, projects safety considerations, rework due to construction errors.
Finance	Insufficient owner or contractor financing
Exogenous conditions	Bad weather conditions, unpredictable surface and subsurface conditions

Examples of these six factors show that poor management is the biggest cause of delays in housing projects, so that the application of lean construction principles is expected to overcome these problems.

### 3.5 Paper Review Related Implementation of Lean Construction in a Housing Project

Academics and professionals in the construction sector are still researching how to implement lean construction principles and techniques in various countries up to the present. In the following table summarizes the implementation of lean construction in various countries on housing projects.

**Table 2.** Lean construction implementation in the housing project

Article	Country	Method	Conclusion
[2]	India	Observation and interview	The use of time impact analysis in real estate projects is useful to reduce waste and function as a socio-technical system that trains workers to reduce delays.
[6]	South America and Africa	Literature study and case study	Lean construction can increase profits and quality in low-cost housing construction. However, it requires the involvement of companies to apply the lean philosophy, because this is the key to getting better results, reducing losses and increasing productivity.
[19]	South America	Literature study and case study	Lean implementation can increase value, save costs, and accelerate project completion.
[20]	Trinidad and Tobago	Literature study and interview	The use of energy, material and time resources is effective after the principles of lean construction are applied. In addition, quality and customer satisfaction also increases.
[21]	Chile	Literature study and case study	The application of lean construction requires a lot of effort to convey value from the customer's perspective, where project control and planning are the most important things that must be considered.

Based on literature study above shows that lean construction can be applied to housing projects and can provide benefits such as reduce waste, reduce delay, increase profits and quality, increase value, accelerate project completion, and increase customer satisfaction.

### 3.6 Barriers of Implementing Lean Construction Practices

Lean construction is very useful for increasing productivity in construction projects, but there are various kinds of challenges that must be faced in its implementation. The following table describes the barriers of implementing lean construction in several countries.

**Table 3.** Main barriers of implementing lean construction in several countries

Article	Country	Main Barriers
[5]	South Africa	Poor culture among project partners, lack of good policies, complexity of lean construction process, poor organizational knowledge, lack of understanding of lean construction, takes time to adopt, inherently knowledge-intensive, lack of skill in lean construction process.
[9]	China	Lack of a long-term philosophy, absence of a lean culture in the organization, limited use of design-and-build procurement mode, insufficient knowledge of lean, multi-layer subcontracting, Limited use of off-site construction techniques, Insufficient management skills.
[22]	Nigeria	Lack of lean awareness and understanding, lack of exposure to the need to



Article	Country	Main Barriers
		adopt the lean concept, lack of proper training, lack of proper training, difficulty in understanding lean concepts, weak communication among clients, consultants and contractors, waste accepted as inevitable.
[23]	Kingdom of Saudi Arabia	<sup>8</sup> Influence of traditional practices, unfavourable organisational culture, lack of technical skills about lean techniques, lack of understanding of lean approaches.

From various countries, it can be seen that the difficulty that often arises in the implementation of lean construction is work culture problem. The second difficulty that often arises is lack of understanding about lean principles in the company. Therefore, the right strategy is needed to overcome these problems.

### 3.7 Proposed Strategies for Implementing Lean Construction Principles in Housing Projects

Basically housing projects have the same problems in implementing lean construction, work culture and lack of knowledge about lean construction are the most common causes faced by construction workers. Therefore the company must be open and committed to making changes, this can be achieved by incorporating lean construction values into company regulations. If this happens, employees and organizational partners will be forced to embrace a lean construction culture [23]. Commitment to implementing lean construction practices must be supported by good managerial skills to oversee the successful implementation of lean construction during the project. Furthermore, enabling employee participation in decision making related to lean construction will build their trust and support for the implementation of lean construction [9].

## 4. Conclusions

The main purpose of this paper is to review the causes of delays in housing projects and recommend the implementation of lean construction to improve the performance of the company. From the reviewed literature shows that the implementation of lean construction can provide benefits to residential project such as reducing waste, work time becomes more effective, improves building quality, saves work costs, and increases customer satisfaction.

However, in applying lean construction there are barriers that must be overcome. The two most common hindrances are work culture and lack of knowledge about lean construction principles. To change the obsolete work culture and provide knowledge about lean construction to employees, it is necessary to incorporate lean values into company regulations. In addition, to keep the company consistent in implementing lean construction principles, good managerial capabilities are needed and involve employees participation in decision making.

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