

# The Effect of Construction Process Sustainability, Material Efficiency, and Time Management on Commercial Building Project Productivity in Tangerang

Mohammad Gifari Sono<sup>1</sup>, Ni Putu Suda Nurjani<sup>2</sup>, Petrus Jhon Alfred D.D<sup>3</sup>

<sup>1</sup> Universitas Muhammadiyah Luwuk

<sup>2</sup> Fakultas Teknik Universitas Mahendradatta

<sup>3</sup> Universitas Flores

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## ABSTRACT

This study examines the influence of construction process sustainability, material efficiency, and time management on the productivity of commercial building projects in Tangerang. Employing a quantitative approach, data were collected from 150 respondents, including project managers, site engineers, and supervisors, through a structured questionnaire using a Likert scale of 1-5. Data analysis was conducted using SPSS version 25. The findings reveal that all three factors significantly and positively affect productivity, with time management emerging as the strongest predictor. These results highlight the importance of integrating sustainable practices, efficient resource utilization, and effective scheduling to enhance project outcomes. This study provides actionable insights for stakeholders in the construction industry, contributing to the broader discourse on sustainable and efficient construction practices.

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## Corresponding Author:

Name: Mohammad Gifari Sono  
Institution: Universitas Muhammadiyah Luwuk  
Email: [mohgifari@gmail.com](mailto:mohgifari@gmail.com)

## 1. INTRODUCTION

The construction industry plays a critical role in economic development and urbanization, especially in rapidly growing regions like Tangerang, Indonesia. The construction industry is integral to economic development and urbanization, particularly in rapidly growing regions like Tangerang, Indonesia, where the complexity of commercial building projects necessitates a focus on sustainable and efficient practices. High productivity levels are crucial for project success and competitiveness in the sector, as

the construction industry significantly contributes to Indonesia's economy by generating employment and enhancing infrastructure, which is vital for equitable development [1], [2]. Investment in construction not only attracts reputable companies but also fosters local workforce skills, driving economic growth [1]. However, the construction industry accounts for approximately 40% of global energy use, emphasizing the need for sustainable practices that can mitigate environmental impacts while promoting social and economic benefits [3]. Despite its importance, the sector

faces challenges such as skilled labor shortages and supply chain disruptions, which can hinder productivity [4]. Addressing these issues requires effective construction management strategies, including the application of knowledge and total quality management, to ensure project success and optimize outcomes [5].

In recent years, sustainability in construction processes has emerged as a pressing concern, with a focus on minimizing environmental impact, conserving resources, and ensuring long-term economic viability. Sustainability in construction processes has gained significant attention due to its implications for environmental impact, resource conservation, and economic viability, with sustainable practices aiming to minimize environmental degradation and resource depletion by adopting eco-friendly methods [6]. The integration of sustainable project management, emphasizing the triad of people, planet, and prosperity, is essential for achieving comprehensive outcomes [7]. Material efficiency plays a key role in this effort, as utilizing environmentally friendly materials enhances cost efficiency and project sustainability, with studies highlighting a strong correlation between waste management and financial performance [8]. Circular-oriented practices, including recycling and selective demolition, are also vital for reducing waste and improving resource utilization [9]. Additionally, effective time management is critical for meeting project deadlines and avoiding cost overruns, which can be achieved through innovative project management approaches that prioritize sustainability [10].

Despite their importance, the combined impact of these factors on productivity in the context of Tangerang's commercial building sector has received limited empirical investigation. Tangerang, a vibrant urban hub, has experienced rapid industrialization and commercial growth, resulting in a surge of construction projects. However, challenges such as resource constraints, environmental considerations, and project delays highlight the need for

strategic approaches to improve productivity. This study aims to fill this gap by examining the influence of construction process sustainability, material efficiency, and time management on the productivity of commercial building projects in Tangerang.

## 2. Literature Review

### 2.1 Construction Process Sustainability

Sustainability in construction is increasingly recognized as essential for addressing environmental challenges and resource limitations while promoting economic viability, as the integration of sustainable practices not only mitigates ecological impacts but also enhances operational efficiency and stakeholder satisfaction [10]. Sustainable practices, such as waste minimization and recycling, significantly reduce CO<sub>2</sub> emissions and resource consumption [9], while sustainable project management techniques improve economic efficiency by optimizing resources and reducing rework, leading to cost savings and enhanced project performance [11]. Additionally, engaging stakeholders in sustainable practices fosters a shared commitment to environmental goals, improving project outcomes [12]. However, challenges to adoption persist, including higher upfront costs of sustainable materials and technologies, which can deter stakeholders [7], and limited awareness among clients and construction companies about the long-term benefits of sustainability, further hindering its implementation [7].

### 2.2 Material Efficiency

Material efficiency is essential in construction as it optimizes resource use, minimizes waste, and enhances project productivity, with effective strategies such as just-in-time delivery and recycling playing a crucial role in achieving these goals. The adoption of sustainable materials, including bio-based insulation and recycled composites, significantly reduces environmental impact and enhances resource efficiency [13], [14], while advanced techniques like 3D printing and prefabrication promote efficient material use and energy savings [15]. Effective material management practices, including robust procurement systems and on-site control, improve material availability and minimize waste, with studies highlighting six critical factors that positively influence material efficiency through structured management practices [16]. Additionally, benchmarking material use efficiency (MUE) through data envelopment analysis enables projects to identify performance gaps and establish improvement targets, as demonstrated in a case study on healthcare projects, where benchmarking led to enhanced material efficiency and reduced environmental impact [17], [18].

### 2.3 Time Management

Effective time management is crucial for the success of construction projects, influencing cost, quality, and stakeholder satisfaction, with structured methodologies such as Critical Chain Project Management (CCPM) and

Earned Value Method (EVM) significantly enhancing project performance by optimizing scheduling and resource allocation. Time management directly correlates with project success, as delays often result in budget overruns and quality issues [19]. Advanced scheduling tools, including Building Information Modeling (BIM) and project management software, further improve accuracy and reliability [20]. Strategies like CCPM align resource availability with project timelines to reduce idle time [21], while EVM provides a comprehensive overview of project performance, enabling timely adjustments to avoid delays [22]. High-rise projects present unique challenges due to their complexities, necessitating robust communication and risk management strategies [20]. Moreover, inadequate planning and unforeseen disruptions underscore the importance of proactive time management practices [23].

### 2.4 Relationship Between Factors and Productivity

The interplay between construction process sustainability, material efficiency, and time management significantly enhances project productivity, as integrating sustainable practices optimizes material usage and streamlines project timelines, creating a synergistic effect. Green Project Management (GPM) incorporates sustainability principles throughout the construction lifecycle, reducing environmental impacts and improving resource efficiency [24], while minimizing

waste enhances material efficiency and accelerates project timelines [25]. Efficient material management is critical, as construction materials represent over 70% of project costs [26], and lean construction principles that focus on waste reduction align with sustainable practices to improve both material management and project schedules [25]. Effective time management ensures the seamless implementation of sustainable and efficient practices, reducing delays and boosting productivity [26]. A holistic approach that integrates sustainability, material efficiency, and time management is essential for maximizing productivity in commercial building projects [27], [28].

#### 2.5 Research Gap

While existing literature underscores the importance of sustainability, material efficiency, and time management in construction projects, limited studies have examined their combined impact on productivity, particularly in the context of Tangerang's commercial building sector. This research seeks to address this gap by exploring how these factors collectively influence productivity and providing actionable insights for stakeholders in the construction industry. By building on existing knowledge, this study aims to contribute to the development of integrated strategies for sustainable and efficient construction practices, ultimately enhancing the productivity of commercial building projects in Tangerang.

### 3. METHODS

#### 3.1 Research Design

This study employs a quantitative research design to investigate the relationships between the independent variables (construction process sustainability, material efficiency, and time management) and the dependent variable (productivity). A structured questionnaire was utilized to collect primary data from respondents involved in commercial building projects, allowing for statistical analysis to determine the significance and strength of these relationships.

#### 3.2 Population and Sample

The population for this study includes professionals engaged in commercial building projects in Tangerang, such as project managers, site engineers, architects, and supervisors. Using purposive sampling, 150 respondents were selected based on their expertise and involvement in project execution. This sample size is deemed sufficient for reliable statistical analysis and generalization within the context of Tangerang's construction industry.

#### 3.3 Data Collection

Data were collected through a structured questionnaire designed to measure the variables of interest, comprising two sections. The first section captured demographic information, including respondents' profiles, job roles, years of experience, and the nature of their involvement in commercial building projects. The second section focused on variable measurement, containing items that assessed construction process sustainability, material efficiency, time management, and productivity using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) to gauge respondents' perceptions and experiences. To ensure clarity and relevance, the questionnaire was pre-tested with a small group of respondents prior to full-scale data collection, and adjustments

were made based on feedback to enhance its validity and reliability.

### 3.4 Data Analysis

The collected data were analyzed using SPSS version 25 through a systematic process. Descriptive statistics were used to summarize respondents' demographic characteristics and calculate mean scores for each variable. Reliability and validity testing included Cronbach's alpha tests to evaluate the questionnaire's reliability and confirmatory factor analysis to ensure construct validity. Correlation analysis was performed to examine the relationships between the independent variables and the dependent variable, while multiple regression analysis identified the influence of construction process sustainability, material efficiency, and time management on productivity.

## 4. RESULTS AND DISCUSSION

### 4.1 Descriptive Statistics

Descriptive statistics provide an overview of the respondents' demographic characteristics and their perceptions of the variables under study. Among the 150 respondents, 40% were project managers, 35% site engineers, and 25% supervisors. A significant portion of the respondents (65%) had over 5 years of experience in construction projects, and 70% were engaged in projects focused on commercial buildings, indicating a well-experienced sample relevant to the study's context.

The mean scores for the variables highlight a generally high perception of their implementation and impact on productivity. Construction process sustainability recorded a mean score of 4.13 (SD = 0.56), material efficiency scored 4.24 (SD = 0.48), time management achieved the highest mean of 4.32 (SD = 0.51), and productivity scored 4.04 (SD = 0.58). These findings suggest that respondents recognize the significant role these factors play in enhancing the productivity of commercial building projects.

### 4.2 Reliability and Validity Testing

Cronbach's alpha values for all variables exceeded the acceptable threshold of 0.70, indicating high internal consistency, with construction process sustainability scoring  $\alpha = 0.855$ , material efficiency  $\alpha = 0.882$ , time management  $\alpha = 0.869$ , and productivity  $\alpha = 0.874$ . Additionally, confirmatory factor analysis validated that all items significantly loaded onto their respective constructs, thereby establishing construct validity for the measurement model.

### 4.3 Correlation Analysis

Pearson correlation coefficients revealed significant positive relationships between the independent variables and productivity, with construction process sustainability and productivity showing a correlation of  $r = 0.653$  (sig 0.000), material efficiency and productivity at  $r = 0.72$  (sig 0.000), and time management and productivity at  $r = 0.76$  (sig 0.000). These findings suggest that improvements in sustainability, material efficiency, and time management are associated with higher productivity in commercial building projects.

### 4.4 Multiple Regression Analysis

Multiple regression analysis was conducted to examine the individual and combined effects of the independent variables on productivity. The model was found to be statistically significant ( $F = 42.372$ , sig 0.000) with an adjusted  $R^2$  value of 0.68, indicating that 68% of the variance in productivity can be explained by the independent variables. This result highlights the substantial influence of construction process sustainability, material efficiency, and time management on productivity in commercial building projects.

The standardized coefficients further detail the contributions of each variable, with construction process sustainability having a coefficient of  $\beta = 0.346$  (sig 0.000), material efficiency  $\beta = 0.418$  (sig 0.000), and time management showing the strongest influence with  $\beta = 0.475$  (sig 0.000). These findings underscore the importance of all three factors in driving productivity, particularly the critical role of effective time management.



### Discussion

The results indicate that all three independent variables have significant positive effects on productivity. Among them, time management had the strongest influence, suggesting that efficient planning and scheduling are critical for achieving high productivity in commercial building projects. This aligns with previous studies by [21], [29], [30], which emphasize the role of time management in reducing delays and optimizing resource utilization.

Material efficiency also emerged as a significant predictor of productivity, consistent with findings by [31]–[33], who highlighted the cost and time savings associated with efficient material usage. This underscores the importance of adopting strategies such as recycling and just-in-time delivery in construction projects.

Construction process sustainability significantly contributes to productivity, reinforcing the notion that eco-friendly practices and waste minimization positively impact project outcomes. These findings support the work of [9], [34], [35], who identified sustainability as a driver of efficiency in construction projects.

### Implications

The findings have practical implications for stakeholders in the construction industry. Project managers and policymakers should prioritize time management strategies, such as advanced scheduling tools, to enhance productivity. Additionally, promoting material efficiency through resource optimization and sustainability practices can yield both environmental and economic benefits.

### Limitations and Future Research

While this study provides valuable insights, it is limited to commercial building

projects in Tangerang. Future research could expand the scope to include other regions or types of construction projects. Additionally, qualitative approaches could complement the quantitative findings by exploring stakeholders' perspectives in greater depth.

## 5. CONCLUSION

This study provides empirical evidence on the significant influence of construction process sustainability, material efficiency, and time management on the productivity of commercial building projects in Tangerang. Among the three factors, time management has the strongest impact, indicating its pivotal role in ensuring timely project completion and optimal resource utilization. Material efficiency and sustainability also play critical roles, highlighting the need for eco-friendly practices and efficient use of construction resources to enhance productivity.

The findings underscore the necessity of adopting holistic approaches that integrate these three dimensions to improve project outcomes in the construction sector. For project managers and policymakers, the results offer practical guidance on prioritizing strategies that balance sustainability, efficiency, and scheduling. By implementing these strategies, stakeholders can achieve higher productivity levels while aligning with sustainable development goals.

Future research should consider expanding the geographical scope or exploring additional variables that may influence productivity, such as technological innovation and stakeholder engagement. Moreover, combining qualitative methods could provide deeper insights into the challenges and opportunities in adopting sustainable and efficient practices in construction.

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