



Impact of Overtime Work on Construction Labor Productivity: Evidence from Work Sampling Analysis of Finishing Activities



Lendra^{1*}, Muhammad I. R. Resnawan¹, Waluyo Nuswantoro¹, Andi²

¹ Department of Civil Engineering, Palangka Raya University, 73112 Palangka Raya, Indonesia

² Department of Civil Engineering, Petra Christian University, 60236 Surabaya, Indonesia

* Correspondence: Lendra (lendraleman@jts.upr.ac.id)

Received: 02-11-2026

Revised: 04-15-2026

Accepted: 04-23-2026

Citation: Lendra, M. I. R. Resnawan, W. Nuswantoro, and Andi, "Impact of overtime work on construction labor productivity: Evidence from work sampling analysis of finishing activities," *J. Eng. Manag. Syst. Eng.*, vol. 5, no. 2, pp. 156–177, 2026. <https://doi.org/10.56578/jemse050203>.



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Abstract: Construction projects frequently encounter field constraints that affect cost, schedule, and quality performance. When delays arise, contractors often adopt overtime work as an acceleration strategy using the existing workforce. However, such practices may lead to concerns regarding productivity decline. This study investigates the impact of overtime work on construction labor productivity based on the Five-Minute Rating method, focusing on plastering and skim coating activities in a residential project in Palangka Raya, Indonesia. A systematic work sampling approach was employed, comprising 1,296 observations collected over six days, with comparisons made between regular working hours and overtime periods. The results indicate distinct productivity responses across work types. Plastering exhibited only a marginal reduction in Labor Utilization Rate (LUR) of approximately 1%, whereas skim coating showed a more pronounced decline of about 6.5% during overtime. Effective activities decreased by approximately 6% under overtime conditions. In contrast, volume-based analysis suggests that output increased during overtime, with gains of 28% for plastering and 49% for skim coating. Statistical analysis suggested a significant difference in productivity for skim coating ($p = 0.031$), while no statistically meaningful difference was observed for plastering ($p = 0.109$) at the 95% confidence level. Despite the observed increase in output, the achieved productivity levels remain below standard unit price analysis benchmarks.

Keywords: Construction management; Labor productivity; Finishing activities; Five-Minute Rating; Labor Utilization Rate; Overtime work; Work sampling

1 Introduction

Labor productivity is widely regarded as a key indicator of sustainable development potential and industrial competitiveness, and it has long been a central concern in economic and project management research [1]. In construction projects, effective management depends on the ability to identify factors that constrain labor performance and to implement practical measures to address them [2]. As a labor-intensive industry, construction relies heavily on human resources as the primary production input, making labor productivity a critical factor influencing project cost, schedule, and overall financial outcomes [3].

In practice, overtime work is frequently adopted as a straightforward approach to accelerating project progress without increasing workforce size. This approach is particularly common in projects where workers are recruited from distant regions and accommodated on-site, making extended working hours relatively easy to implement. However, previous studies have shown that overtime does not always lead to improved performance and may, in some cases, reduce productivity [4]. Such effects are often associated with prolonged working hours under schedule pressure. In addition, project characteristics, including scale and complexity, have also been found to influence labor productivity, with larger projects often facing greater efficiency challenges [5].

Even relatively small reductions in productivity can have noticeable effects on project planning and execution. A key question is whether such reductions are linked to increased non-productive time or to inefficiencies in work organisation during extended working periods. This issue is particularly relevant when evaluating the actual effectiveness of overtime as a management strategy in construction practice.

Most existing research on construction labor productivity has been conducted in developed or region-specific contexts, while systematic evidence from developing countries remains comparatively limited. The Indonesian construction sector, in particular, presents distinct working conditions, labour practices, and project environments that may influence productivity outcomes. By focusing on finishing activities, namely plastering and skim coating, this study examines productivity behaviour in a setting that reflects common residential construction practice.

From a methodological perspective, this study applies the Five-Minute Rating method in combination with statistical analysis to examine differences in productivity between regular and overtime working conditions. The results are intended to provide empirical evidence to support decision-making in construction management, especially in relation to the use of overtime work.

The study addresses two main questions. First, to what extent overtime work affects labor productivity in finishing activities. Second, whether this effect varies between work types that differ in terms of precision requirements. In addition, the study considers whether any loss in efficiency during overtime is offset by changes in output volume, and discusses the implications for practical project management.

2 Literature Review

2.1 Construction Management and Labor Productivity

Construction project management involves the coordination of resources, processes, and personnel to achieve project objectives within specified time and cost constraints [4, 6, 7]. Within this context, labor productivity plays a central role, as it directly affects project performance in terms of efficiency, schedule adherence, and cost control.

In construction practice, labor productivity reflects the effectiveness with which human resources are utilised to generate output. It is not only influenced by worker skills and experience, but also by management practices, work organisation, and site conditions. As a result, improving labor productivity requires more than technical capability; it depends on how work is planned, supervised, and executed at the project level.

Previous studies have identified a range of factors that shape labor productivity, including management-related aspects such as planning and coordination, labor-related characteristics such as motivation and skill level, and project-specific conditions such as complexity and location [8–10]. These findings suggest that productivity is inherently context-dependent, and that management decisions play a critical role in determining how effectively labor resources are deployed in construction projects.

2.2 Theoretical Framework of Productivity

Productivity fundamentally represents the relationship between actual field results and input resources, serving as a crucial indicator for measuring sustainable development potential and industrial competitiveness [11]. Yi and Chan [12] identified in their comprehensive review that construction labor productivity definitions vary depending on usage perspectives, stating that “labor productivity is a crucial productivity index because of the concentration of human labor needed to complete a specific task.” This definition emphasises the human-centric nature of construction activities and the critical role of workforce efficiency in project outcomes.

Construction productivity measurement involves comparing output achievements with input investments, where higher productivity levels correlate with improved project accuracy and reduced waste of resources. Labor productivity measures explicitly workforce utilization efficiency, recognising that workers may not always utilise their full capabilities during task execution [2]. This reality necessitates systematic approaches to understanding and optimising labor performance in construction environments.

Dozzi and AbouRizk [13] identified several primary factors influencing construction labor productivity: (1) management factors including planning, supervision, and coordination; (2) labor factors such as skills, experience, and motivation; (3) project factors including complexity, size, and location; and (4) external factors such as weather conditions and regulatory requirements. Within the Indonesian context, Soekiman et al. [14] identified that supervisor effectiveness, worker experience, and material availability are the three most critical factors affecting construction labor productivity, underscoring the importance of local contextual considerations in productivity analysis.

Research on factors influencing construction labor productivity has been extensively conducted across various countries, providing valuable insights into regional variations and universal principles. El-Gohary and Aziz [3] identified and ranked factors affecting construction labor productivity in Egypt, categorising them into three primary categories: human and labor factors, industrial factors, and management factors. This classification framework provides a systematic approach to understanding productivity determinants and developing targeted improvement strategies.

2.3 Overtime Work and Productivity Impact

Research on the relationship between overtime work and construction productivity has produced mixed findings. While extended working hours are often introduced to accelerate project progress, their impact on productivity is not uniform across studies. Empirical evidence suggests that prolonged overtime, particularly when implemented

as a regular scheduling practice, tends to reduce labor efficiency [15]. In contrast, moderate or occasional overtime appears to have a more limited effect on productivity and may, under certain conditions, support short-term output targets [15].

These differences indicate that the impact of overtime is closely related to the characteristics of the work and the conditions under which it is implemented. Tasks requiring sustained concentration and precision are more likely to be affected by fatigue, whereas repetitive or routine activities may be less sensitive to extended working hours. In addition, managerial decisions regarding the timing, duration, and allocation of overtime play a key role in shaping productivity outcomes [15].

Overall, the relationship between overtime work and productivity can be understood as context-dependent rather than uniform. This perspective highlights the importance of activity-level analysis when evaluating overtime strategies in construction projects, particularly in terms of how different work types respond to extended working periods.

2.4 Work Sampling Methodology

Work sampling, also known as activity sampling, represents a statistical technique for measuring and analysing productivity by applying statistical principles to both effective and ineffective activities through random sampling that represents the entire population [16]. This methodology enables systematic analysis of worker behaviour patterns and productivity levels through structured observation protocols.

The fundamental principles of work sampling methodology, as established by Oglesby et al. [17], include several critical requirements: observers must quickly identify individuals for proper classification; sample observations should not fall below 384 observations for statistical validity; samples must be collected from various portions of the labor cycle to ensure equal observation opportunities; random sampling must represent group characteristics without showing special conditions that could bias observations; and recording must be conducted quickly and decisively to avoid bias, documenting initial observations accurately.

The work sampling methodology has been widely applied in the construction industry for measuring productivity. Gong et al. [18] utilised this method to analyse construction worker productivity in China, finding that effective time utilization ratios ranged between 50% and 70%, depending on work type and project conditions. Within Indonesia, Andi et al. [19] applied the work sampling methodology to building construction projects in Surabaya, discovering an average Labor Utilization Rate (LUR) of 55.46%, which indicates significant potential for productivity improvement

2.5 Labor Utilization Rate Framework

LUR represents the percentage obtained from summing practical work with essential contributory work, then dividing this sum by total observations [16, 20]. LUR measures workforce utilization effectiveness by categorising time into adequate work time, contributory work time, and ineffective work time [21]. While LUR can determine worker effectiveness in projects, it cannot explain why values are low or high [19], necessitating the use of complementary analysis methods for a comprehensive productivity assessment.

The LUR framework establishes that work teams achieve effective time utilization when their labor utilization factor exceeds 50%. Adequate time represents periods when workers are engaged in activities classified as work, while ineffective time encompasses activities classified as non-work. Activity classification in this methodology is not absolute, allowing for adaptation to field conditions to obtain the necessary data [17]. This flexibility enables researchers to adjust classification criteria based on specific project requirements and observational constraints.

2.6 Five-Minutes Rating Method

The Five-Minutes Rating method ensures that no worker remains unobserved for less than five minutes, helping to identify excessive non-productive time and reflecting the effectiveness of workface planning [18]. This method is based on observation numbers conducted within short, relatively quick timeframes, though it may be less accurate than Field Rating methods [17]. The Five-Minutes Rating approach provides a practical balance between observation frequency and data collection efficiency based from previous research [22]. The study implemented the Five-Minutes Rating methodology, validated by Oglesby et al. [17] and empirically applied in construction productivity studies by Sonmez [15] and Dozzi and AbouRizk [13].

Implementing the Five-Minute Rating method requires the use of systematic observation protocols with consistent time intervals. The method's effectiveness depends on observer training, standardised recording procedures, and appropriate sampling strategies that capture representative work patterns. When properly implemented, this method provides reliable data for productivity analysis while maintaining practical feasibility for field research applications [17, 18].

2.7 Productivity Measurement in Indonesian Construction Context

Research on construction productivity within the Indonesian context reveals specific characteristics that differentiate local practices from international standards. Cultural factors, work organisation patterns, and regulatory frameworks contribute to unique productivity patterns that require specialised investigation. The limited availability of systematic productivity studies in Indonesian construction creates opportunities for valuable research contributions to both local industry practices and international construction management knowledge.

Indonesian construction projects often involve different labor organisation structures, skill development patterns, and project management approaches compared to those examined in Western or Middle Eastern contexts in much of the existing literature. These differences necessitate context-specific research to develop appropriate productivity measurement frameworks and improvement strategies. The current study addresses this research gap by providing empirical evidence from Indonesian construction projects using validated international methodologies.

2.8 Research Gap and Methodological Contribution

The literature review reveals several critical gaps that justify the current research focus. First, geographical, and contextual imbalances exist, as most previous research on construction labor productivity has been conducted in developed countries or the Middle East. In contrast, research within the Indonesian context, with its specific work culture characteristics and operational conditions, remains severely limited. Second, although Sonmez [15] explored the impact of occasional overtime on construction productivity, research integrating work sampling methodology with quantitative analysis of overtime impact requires further development. Third, from a methodological perspective, integrating Five-Minutes Rating techniques with robust statistical analysis frameworks for measuring the impact of overtime on labor productivity requires additional development and validation. Fourth, regarding specific applications, research specifically investigating the overtime impact on work types, such as plastering and skim coating, using work sampling approaches, remains scarce, creating knowledge gaps in this domain.

The current study addresses these gaps by applying the Five-Minutes Rating methodology to measure the impact of overtime work on construction labor productivity within the Indonesian context. This approach provides both methodological contributions through the application of techniques and empirical contributions through context-specific findings. The research framework established in this study can serve as a foundation for future productivity investigations in similar developing country construction environments.

3 Research Methods

3.1 Design and Framework

This study employed a quantitative research approach with an observational design to analyse the impact of overtime working hours on construction labor productivity. The research framework adopted the methodology developed by Yi and Chan [12] for productivity analysis at the activity level, explicitly focusing on finishing work activities in residential construction projects [2]. The study design employs a comparative analysis structure, examining productivity differences between regular working hours and overtime periods using a standardised work sampling technique known as the h Rating method.

The Five-Minutes Rating method was selected over alternative work sampling approaches for three reasons. First, it generates 12 observation data points per hour per worker without requiring specialised instrumentation, continuous video recording, or automated sensor systems, making it particularly practical for simultaneous observation of multiple workers across two teams in a field setting. Second, the method has been validated specifically for construction productivity contexts by Oglesby et al. [17] and has been empirically applied in comparable studies by Sonmez [15] and Gong et al. [18], providing a methodological precedent directly relevant to the present research. Third, compared to alternative approaches such as Field Rating, which records only a binary work or non-work classification at each observation point, and Productivity Rating, which requires continuous stopwatch timing and is more suitable for single-worker studies, the Five-Minutes Rating method offers a more granular activity classification while remaining feasible for field implementation with a small observer team. Automated IoT-based observation systems, while capable of higher data density, were not considered appropriate for this study given the project scale and the need for activity-level classification that current sensor technologies cannot reliably perform in unstructured construction environments. Future research incorporating such technologies is identified as a priority direction in Section 5.3.

The research framework is illustrated in Figure 1, which presents the systematic approach for data collection, analysis, and interpretation. This framework ensures methodological rigour while maintaining practical applicability for construction industry contexts. The observational design enables the direct measurement of actual work behaviours without artificial intervention, providing authentic insights into productivity patterns under different working hour conditions.

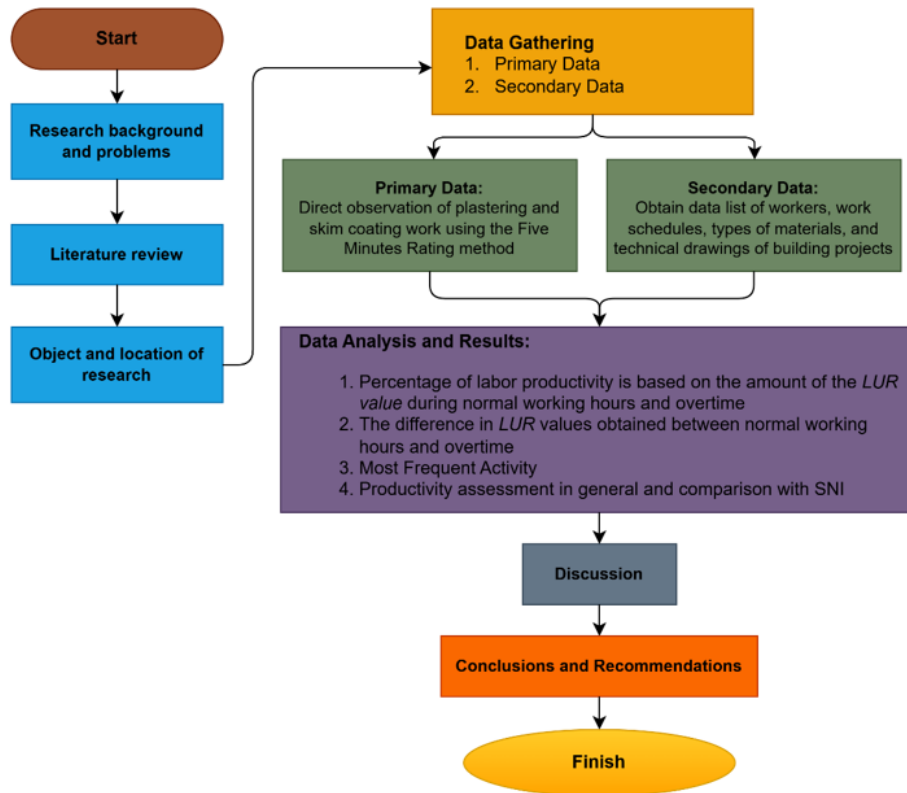


Figure 1. Research flow diagram

3.2 Study Location and Project Description

The research was conducted through direct field observation at a two-story residential construction project (Type 500) located on Yos Sudarso Street, Palangka Raya, Indonesia. The construction site encompasses approximately 560 m² of land area, representing typical residential development characteristics common in Central Kalimantan Province. The project selection criteria included active finishing work phases, the availability of skilled labor teams, and the contractor’s willingness to participate in productivity measurement activities. Field observations were conducted during June–December 2025, coinciding with the active finishing phase of the project.

The scope of work observation focused specifically on plastering and skim coating activities on the second floor, performed by a total of six workers organised into two specialised teams. These finishing activities were selected due to their labor-intensive nature, standardised work procedures, and significant contribution to overall project completion timelines. The work teams consisted of experienced artisans with comparable skill levels, ensuring consistency in baseline productivity capabilities across observation periods.

3.3 Data Collection Strategy

3.3.1 Observation period design

Data collection was conducted over six non-consecutive days using a randomized sampling approach to capture representative work patterns while avoiding potential bias from consecutive observation effects. The observation schedule was strategically distributed across four regular working hour periods (comprising two morning cycles and two afternoon cycles) and two overtime working hour periods, as illustrated in Figure 2. This distribution ensures balanced representation of productivity patterns across different work periods while maintaining statistical validity requirements.

The randomized, non-consecutive observation approach minimizes potential Hawthorne effects, where the continuous presence of observers might artificially influence worker behaviour. Additionally, this strategy captures natural productivity variations that occur across different workdays, weather conditions, and project phases, providing more robust and generalizable findings.

3.3.2 Five-Minutes Rating methodology implementation

The observation protocol was structured with five-minute intervals over one-hour sessions, generating 12 observation points per session for each worker. With three workers observed simultaneously per team, each

observation session produced 36 data points, resulting in 216 observations per day across both work teams.

Data recording procedures utilised standardised forms specifically designed to capture time allocation patterns for each worker during plastering and skim coating activities. The primary focus centred on measuring the impact of overtime work on productivity through changes in LUR calculations. Implementation involved trained observer teams consisting of one to two qualified personnel to ensure accuracy and consistency in activity classification and time recording.

The observation timing followed established work sampling principles by avoiding transition periods, including the first 30 minutes after work commencement, 30 minutes following lunch breaks, and 30 minutes before break periods or work conclusion [16, 17]. This principle was also applied when overtime observatory sessions. This approach ensures data collection during representative work periods while minimising bias from warm-up or wind-down activities that may not accurately reflect typical productivity levels.

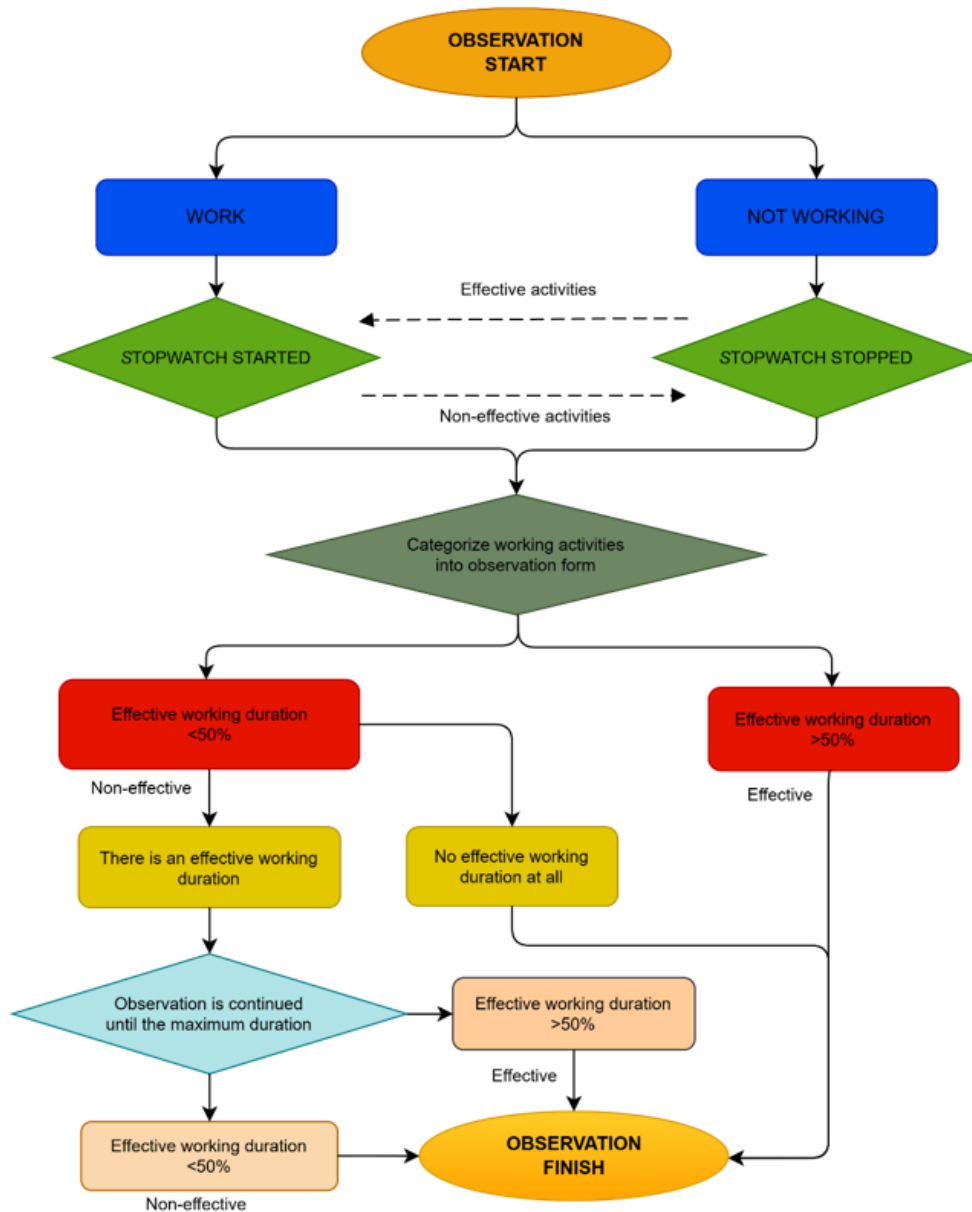


Figure 2. Data gathering method flowchart

Source: Based on the Oglesby et al. [17].

3.4 Measurement Validity and Reliability

3.4.1 Validity assurance measures

To ensure measurement validity and reliability, the study followed best practices recommended by Yi and Chan [12] and Sakr et al. [23]. Validity assurance included comprehensive observer training in Five-Minutes

Rating techniques to maintain classification consistency across all observation sessions. The observation forms were designed and validated through consultation with construction management experts, ensuring the appropriate categorisation of activities and effective data capture mechanisms.

A pilot study was conducted over one full day prior to actual data collection to test observation procedures, refine data recording forms, and identify potential implementation challenges. This preliminary phase enabled methodological adjustments and observer calibration, thereby enhancing overall data quality and collection efficiency.

3.4.2 Reliability verification procedures

Reliability measures encompassed consistent five-minute observation intervals maintained throughout all data collection sessions, ensuring temporal consistency in sampling procedures. The total observation count reached 1,296 data points, substantially exceeding the minimum 384 observations required for valid work sampling analysis [17]. This sample size provides sufficient statistical power for detecting meaningful productivity differences between regular and overtime working conditions.

Inter-rater reliability was verified through consistency testing between observers using Cronbach's Alpha coefficient, achieving a value of 0.87, which indicates high reliability in observation classification and recording procedures. This reliability measure ensures that different observers would classify the same activities consistently, supporting the validity of comparative analyses between different observation periods.

3.5 Data Analysis Framework

3.5.1 Labor Utilization Rate calculation

The primary analytical approach employed LUR calculations using the formula established by Pilcher [16]:

$$\text{Labor Utilization Rate} = \frac{t_{\text{eff}}}{t} \times 100\% \quad (1)$$

where, t represents total observation time; t_{eff} represents total effective working time.

Eq. (1) provides the fundamental metric for comparing productivity levels between regular working hours and overtime periods. The analysis begins with a productivity assessment based on observational data, followed by a comparative evaluation of potential productivity changes resulting from different working hour conditions. If analysis results indicate productivity levels below expected targets, the findings inform recommendations for optimal overtime work policies to enhance overall efficiency.

3.5.2 Statistical analysis procedures

The statistical analysis framework adopted methodological approaches from Sonmez [15] for the validation of construction productivity, incorporating multiple analytical techniques to ensure robust findings. The primary statistical procedures include:

- Normality Testing: Anderson-Darling tests were employed to validate standard distribution assumptions for parametric statistical analysis. This testing ensures the appropriate selection of subsequent analytical procedures based on data distribution characteristics.
- Comparative Analysis: Two-sample t -tests were used to examine significant productivity differences between regular working hours and overtime periods, provided the data met the assumptions of normality. For non-normally distributed data, the Wilcoxon rank sum test served as a non-parametric alternative, ensuring appropriate statistical inference regardless of the data distribution patterns.

Significance Evaluation: All statistical tests employed a 95% confidence level ($\alpha = 0.05$) for determining significance, providing robust evidence for detecting productivity differences while maintaining acceptable Type I error rates.

3.5.3 Activity decline analysis

Quantitative assessment of effective activity changes utilized the following calculation framework:

$$\text{Decrease in Relative Activity} = \frac{\text{Initial Value} - \text{Final Value}}{\text{Initial Value}} \times 100\% \quad (2)$$

Eq. (2) enables the systematic measurement of productivity changes between regular and overtime working conditions, providing quantifiable evidence for assessing the impact of overtime work. This calculation approach facilitates direct comparison of activity levels and supports evidence-based recommendations for construction management practices.

3.6 Quality Control and Data Integrity

3.6.1 Observation protocol standardization

Quality control measures included standardised observation protocols, ensuring consistent data collection across all sessions and observers. Observer training emphasised rapid, decisive activity classification to minimise subjective interpretation variations and maintain data consistency. Regular calibration sessions were conducted throughout the data collection period to ensure the continued reliability of the observer and classification accuracy.

3.6.2 Data validation procedures

Data integrity was maintained through immediate field verification of recorded observations, cross-checking between multiple observers when available, and systematic review of data completeness and logical consistency. Any questionable observations were flagged for further review or exclusion from analysis to ensure data quality standards were maintained.

The comprehensive data collection approach yielded a robust dataset comprising 1,296 observation points, distributed across six observation days, with a balanced representation between regular working hours (864 observations) and overtime periods (432 observations). This dataset provides sufficient statistical power to detect meaningful productivity differences while maintaining the representativeness of typical construction work patterns.

3.6.3 Analytical framework integration

The integrated analytical framework combines work sampling methodology with statistical analysis to provide comprehensive insights into the effects of overtime work on construction labor productivity. This approach enables both descriptive analysis of productivity patterns and inferential statistics for determining significant differences between working hour conditions.

The methodology framework established in this study provides a replicable approach for future construction productivity research, particularly in developing country contexts where systematic productivity measurement may be limited. The combination of internationally validated techniques with local construction industry characteristics creates a robust foundation for evidence-based construction management practices.

4 Data Analysis

4.1 Overview of Data Collection Outcomes

The comprehensive field observation conducted at the two-story residential construction project successfully collected systematic data on construction labor productivity for plastering and skim coating activities. Following the research framework illustrated in Figure 1, the study involved six construction workers organised into two specialised teams: three workers focused on plastering operations and three workers dedicated to skim coating tasks, with each team observed over three working days. The implementation of the Five-Minutes Rating methodology, as depicted in the data gathering flowchart shown in Figure 2, resulted in five-minute observation intervals generating a total of 1,296 data points, comprising 648 observations for each work type.

Data quality assurance was maintained through adherence to established work sampling standards recommended by Pilcher [16] and Oglesby et al. [17]. Observations were conducted during representative work periods, deliberately avoiding transition phases including the initial 30 minutes after work commencement, 30 minutes following lunch breaks, and 30 minutes preceding break periods or work conclusion. Each observation session lasted one hour, with 36 observations recorded per session across three workers, resulting in a total of 108 daily observations. The resulting dataset provides comprehensive insights into work patterns, time efficiency, and productivity performance for plastering and skim coating activities, establishing a robust foundation for construction performance analysis and project planning applications.

4.2 Labor Utilization Rate Analysis by Type of Work and Working Hours

4.2.1 Comparative Labor Utilization Rate performance between work types

The analysis reveals significant differences in LUR performance between plastering and skim coating activities under normal working hour conditions, as presented in Table 1. For plastering work, LUR values demonstrated a progressive improvement pattern, increasing from 53.47% on the first day to 57.64% on the second day and reaching 59.72% on the third day. This upward trend suggests a learning curve effect where workers gradually improved their efficiency as they became more familiar with the specific work requirements and site conditions, consistent with findings from Indonesian construction productivity studies that identify worker experience as a critical factor [14, 23].

In contrast, skim coating activities exhibited higher baseline LUR values with a fluctuating pattern: 62.50% on day four, peaking at 70.14% on day five, then decreasing to 67.36% on day six. These results indicate that skim coating work demonstrates superior time utilization efficiency compared to plastering activities, with average regular working hour LUR values of 66.67% for skim coating versus 56.94% for plastering work. This difference

can be attributed to the distinct technical requirements and skill demands associated with each finishing technique, supporting research that emphasises the role of work complexity in determining productivity levels [20, 24].

Table 1. Observation results of effective activities

Types of Work	Day	Regular Working Hours			Overtime Working Hours		
		Productive Work	Idle Time	LUR (%)	Productive Work	Idle Time	LUR (%)
Plastering	1	77	67	53.47	40	32	55.56
	2	83	61	57.64	40	32	55.56
	3	86	58	59.72	41	31	56.94
Average				56.94			56.02
Skim coating	4	90	54	62.50	44	28	61.11
	5	101	43	70.14	44	28	61.11
	6	97	47	67.36	42	30	58.33
Average				66.67			60.19

Note: LUR = Labor Utilization Rate.

The observed LUR values align with international standards for construction work sampling studies, where effective performance is typically indicated by values exceeding 50% [17, 19]. The superior performance of skim coating work is consistent with recent studies on specialised construction activities that require higher skill levels and precision, often resulting in more focused work patterns [25, 26].

4.2.2 Overtime work impact on labor utilization

The overtime working hour analysis reveals contrasting productivity patterns compared to regular working periods, as clearly illustrated in Figure 3, which shows the LUR comparison between regular and overtime working hours. For plastering work, overtime LUR values remained relatively stable with slight improvements from 55.56% on days one and two to 56.94% on day three. This stability suggests that plastering workers maintained consistent performance levels during extended working hours, possibly due to the repetitive nature of the work and established rhythm patterns.

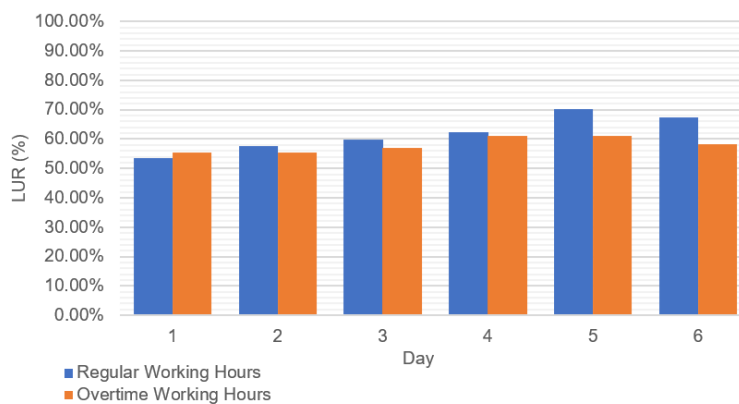


Figure 3. Labor Utilization Rate (LUR) comparison chart between regular and overtime working hours

However, skim coating work during overtime periods showed a declining trend from 61.11% on days four and five to 58.33% on day six. This pattern indicates that skim coating activities may be more susceptible to fatigue-related productivity declines during extended working hours, potentially due to the precision requirements and attention to detail demanded by skim coating techniques. This finding is consistent with recent research on overtime work effects, which indicates that precision-based construction activities are more vulnerable to productivity decline during extended working hours [27, 28].

Despite all LUR values exceeding the 50% threshold, which indicates effective performance according to established work sampling standards [17], the data reveal concerning trends regarding overtime work efficiency. The patterns observed align with international studies showing that construction work requiring higher precision and concentration tends to suffer more significant productivity losses during overtime periods compared to repetitive manual tasks [11, 16].

4.2.3 Quantitative assessment of productivity changes

The quantitative analysis of LUR changes between regular and overtime working conditions reveals measurable impacts on productivity. For plastering work, the calculated difference shows:

$$\begin{aligned} \text{LUR Difference (Plastering)} &= \text{Overtime Hours LUR} - \text{Normal Hours LUR} \\ &= 56.02\% - 56.94\% = -0.92\% \approx -1.0\% \end{aligned}$$

This minimal decrease suggests that plastering activities maintain relatively stable productivity levels during overtime periods, with only slight reductions in efficiency. The small magnitude of change may indicate that plastering work characteristics, including physical demands and skill requirements, are less sensitive to the effects of extended working hours, supporting findings from similar studies on repetitive construction tasks [8, 29].

For skim coating work, the productivity impact proves more substantial:

$$\begin{aligned} \text{LUR Difference (Skim Coating)} &= \text{Overtime Hours LUR} - \text{Normal Hours LUR} \\ &= 60.19\% - 66.67\% = -6.48\% \approx -6.5\% \end{aligned}$$

This significant reduction demonstrates that skim coating activities experience a notable decline in productivity over time. The larger magnitude suggests that the precision and attention requirements of skim coating work make it more vulnerable to fatigue-related performance degradation during extended working hours, consistent with recent research on overtime effects in precision-based construction activities [30, 31].

4.3 Work Activity Pattern Analysis

4.3.1 Comprehensive activity classification and frequency

The systematic observation recorded 1,296 total activities across both work types and working hour conditions. Plastering work involved one skilled laborer (Labor 1) and two unskilled laborers (Labor 2 and 3), while skim coating work involved two skilled laborers (Labor 4 and 5) and one unskilled laborer (Labor 2). Labor 2 participated in both teams to maintain continuity in skill assessment. The activity data were organised according to working hour categories: regular working hours encompassed four observation sessions, and overtime working hours covered two observation sessions, as detailed in Table 2.

Table 2. Comprehensive labor activity classification and frequency

Working Hours	Activity Type (1–22)		Combined	Total
	1–11 (Effective)	12–22 (Non-Effective)		
Regular	534	330	864	864
Overtime	251	181	432	432
Total	785	511	1,296	1,296

Prior to the main data collection phase, a preliminary observation session was conducted to identify all activities performed by workers during plastering and skim coating tasks. These activities were then categorised into two primary categories, with the resulting activity distributions illustrated in the Crew Balance Charts shown in Figures 4 and 5 for regular working hours and overtime periods, respectively.

Figure 4 shows that Activity 10 (main application) dominates the time allocation of all five workers during regular hours, indicating that productive work constitutes most observed activities. However, unskilled laborers (Labors 2 and 3) exhibit more fragmented activity distributions compared to skilled workers, reflecting their broader supporting roles involving material transport, preparation, and waiting periods.

Figure 5 shows that during overtime, the proportion of non-effective activity segments increases noticeably for Labors 4 and 5 (skim coating skilled workers) compared to regular hours, consistent with the quantitative finding of a 6.5% LUR decline for skim coating. The activity distributions of the plastering team (Labors 1, 2, and 3) remain comparatively stable, corroborating the minimal 1% LUR decline observed for plastering work during overtime.

Table 3 presents the complete classification of the 22 activities observed during the study, organised into effective activities (codes 1 to 11) and non-effective activities (codes 12 to 22). Effective activities encompass all actions that directly contribute to plastering or skim coating output, ranging from material preparation and surface treatment to the main application and quality inspection.

Non-effective activities comprise actions that do not advance the work, including waiting time, idle periods, personal activities, and other non-productive behaviour. Activity 10 (Applying plaster or skim coating) emerged as the dominant effective activity across all observation sessions, confirming the appropriateness of the selected observation scope. The prevalence of Activity 12 (Waiting for instructions from supervisor), recorded 94 times

during regular hours and 50 times during overtime periods, indicates that coordination delays represent the most significant source of non-effective time in this project. The detailed activity breakdown provided in the Activities Detail diagram further supports findings from similar work sampling studies in construction [19, 32].

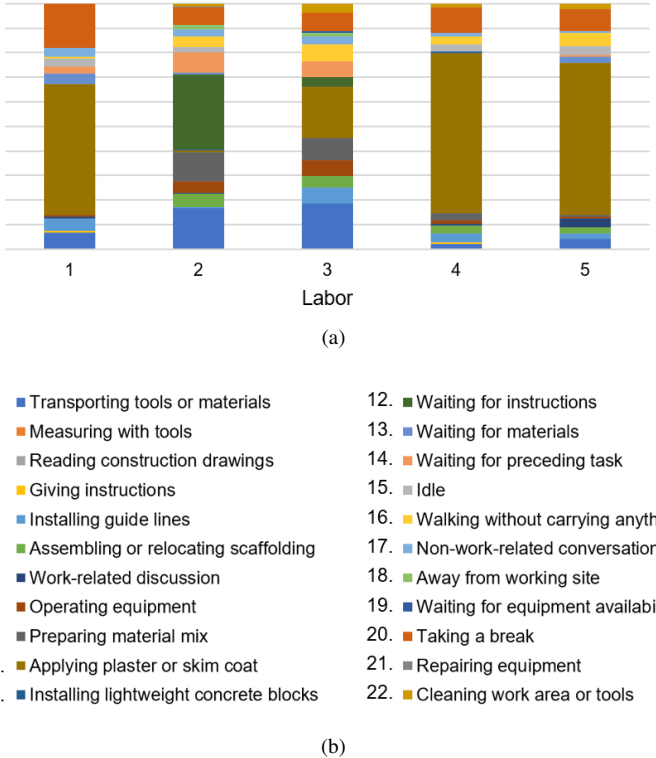


Figure 4. Crew balance chart of regular working hours: (a) crew balance chart; (b) activities detail

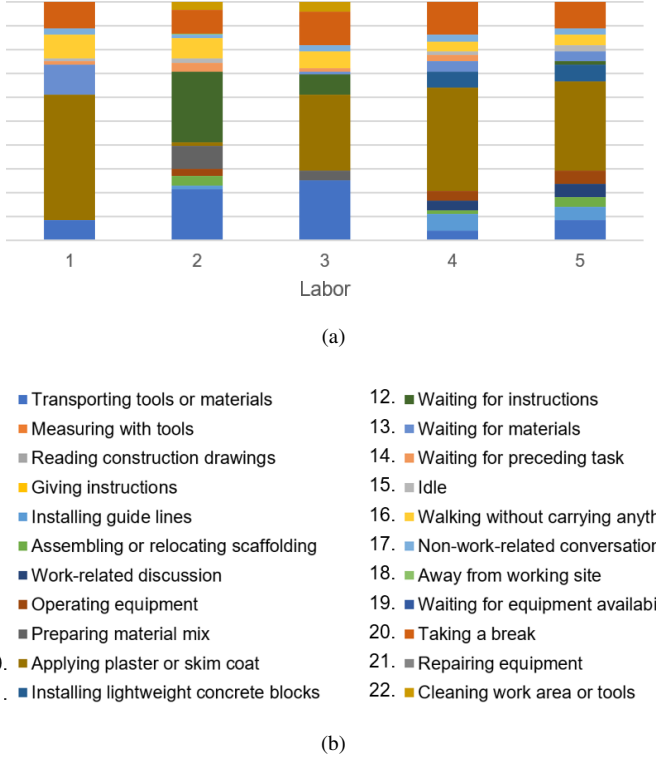


Figure 5. Crew balance chart during overtime: (a) crew balance chart; (b) activities detail

Table 3. Activity classification for plastering and skim coating work sampling

Code	Activity Description	Category
1	Transporting tools or materials	Effective
2	Measuring with tools	Effective
3	Reading construction drawings	Effective
4	Giving instructions	Effective
5	Installing guide lines	Effective
6	Assembling or relocating scaffolding	Effective
7	Work-related discussion	Effective
8	Operating equipment	Effective
9	Preparing material mix	Effective
10	Applying plaster or skim coat	Effective
11	Installing lightweight concrete blocks	Effective
12	Waiting for instructions	Non-effective
13	Waiting for materials	Non-effective
14	Waiting for preceding task	Non-effective
15	Idle	Non-effective
16	Walking without carrying anything	Non-effective
17	Non-work-related conversation	Non-effective
18	Away from working site	Non-effective
19	Waiting for equipment availability	Non-effective
20	Taking a break	Non-effective
21	Repairing equipment	Non-effective
22	Cleaning work area or tools	Non-effective

Note: Activity classification follows the framework established by Oglesby et al. [17], verified through a one-day pilot observation prior to data collection. Activity labels were adapted to reflect the specific finishing operations observed in this study.

4.3.2 Effective activity performance analysis

To determine the overall decline in effective activity during overtime periods, the average number of practical activities per observation session was calculated for each working hour category, as presented in Table 4. This analysis provides insights into how extended working hours influence overall work effectiveness beyond individual LUR measurements, supporting the comprehensive approach to productivity measurement advocated in recent construction research [24, 33].

Table 4. Effective activity performance comparison

Working Hours	Observation Sessions per Day	Total Effective Activities	Average Effective Activities per Session
Regular	4	534	133.5
Overtime	2	251	125.5

The comparative analysis between effective activity levels during regular and overtime working conditions enables calculation of relative productivity decline using Eq. (2):

$$\text{Decrease in Effective Activities} = \frac{125.5 - 133.5}{133.5} \times 100\% = -5.99\% \approx -6\%$$

4.3.3 Non-effective activity pattern identification

Analysis of ineffective activities reveals specific patterns that contribute to productivity limitations during both regular working periods and overtime. Activity 12 (waiting for instructions) occurred most frequently among non-effective activities, recorded 94 times during regular working hours and 50 times during overtime periods. This high frequency indicates significant idle time where workers await direction from supervisors or coordination with other work activities.

The prevalence of waiting time suggests potential improvements in work coordination and communication systems, consistent with findings from Indonesian construction productivity studies that identify supervision and coordination as critical factors affecting labor efficiency [23, 27]. Improved project scheduling, more precise work instructions, and improved communication between supervisors and workers could reduce these unproductive periods and enhance overall labor efficiency.

Activity 20 (rest periods) represented the second most frequent non-effective activity, occurring 86 times during regular hours and 50 times during overtime periods. While rest periods serve important functions for worker health and sustained performance, excessive frequency may indicate inadequate work pacing or insufficient physical conditioning for the required work intensity, aligning with research on occupational health and productivity relationships [11, 34].

4.4 Construction Productivity Analysis Based on Work Volume

4.4.1 Daily work volume performance assessment

Productivity analysis based on actual work volume completion offers a distinct perspective on the effectiveness of overtime work compared to time utilization measurements, as documented in Table 5. The volume-based analysis reveals interesting contrasts with time utilization findings, where, despite showing decreased LUR values during overtime periods, actual work volume achievements demonstrate sustained productivity levels that suggest workers maintain output capacity during extended hours, though potentially at the cost of efficiency as measured by time utilization rates.

Table 5. Daily work volume performance summary

Types of Work	Day	Working Hours		Quantity (m ²)	
		Regular	Overtime	Regular	Overtime
Plastering	1	9	3	29.57	11.98
	2	9	3	26.09	11.51
	3	9	3	26.66	11.52
Skim coating	4	9	2	62.17	20.31
	5	9	2	58.26	21.99
	6	9	2	65.05	19.28

This paradoxical relationship between time efficiency and volume output has been observed in similar studies on construction overtime work, where workers may compensate for reduced efficiency through sustained effort levels during extended working periods [24, 35]. The phenomenon aligns with research suggesting that occasional overtime can maintain volume output even when time utilization efficiency declines [15, 36].

4.4.2 Labor coefficient analysis and Analysis of Unit Price of Work standard comparison

The study compared field-measured productivity with unit price analysis (2024 Analysis of Unit Price of Work (AHSP, *Analisis Harga Satuan Pekerjaan*)) ideal requirements through labor coefficient calculations within equation, as presented in Table 6. This comparison provides insights into how actual construction productivity compares with established national productivity standards and expectations.

Table 6. Labor coefficient comparison with Indonesian national standards

Types of Work	Day	Regular Working Hours			Overtime Hours		
		Foreman	Skilled Labor	Unskilled Labor	Foreman	Skilled Labor	Unskilled Labor
Plastering	1	0.0338	0.0338	0.0676	0.0835	0.0835	0.1669
	2	0.0383	0.0383	0.0767	0.0869	0.0869	0.1737
	3	0.0375	0.0375	0.0750	0.0868	0.0868	0.1736
Average		0.0366	0.0366	0.0731	0.0857	0.0857	0.1714
Skim coating	4	0.0161	0.0322	0.0161	0.0492	0.0985	0.0492
	5	0.0172	0.0343	0.0172	0.0455	0.0910	0.0455
	6	0.0154	0.0307	0.0154	0.0519	0.1037	0.0519
Average		0.0162	0.0324	0.0162	0.0489	0.0977	0.0489

The productivity calculation methodology adjusts for different working hour standards between field conditions (9 regular hours + 2–3 overtime hours = 11–12 total hours) and AHSP Specification (7 standard hours) enabling fair comparison between field measurements and national standards by normalising for different time bases, using Eq. (3):

$$\text{Labor Productivity} = \frac{1}{\text{Coefficient} \times \text{Working Time}} \times \text{Working Time Standard} \quad (3)$$

The comparative analysis presented in Tables 7 and 8 for plastering and skim coating work, respectively, reveals significant disparities between field measurements and national standards. As illustrated in Figures 6 and 7, which compare on-site measured productivity with the Indonesian National Standards for both work types, the field productivity levels fall substantially below established benchmarks, particularly for supervisory positions, while exceeding standards for skilled and unskilled labor positions.

Table 7. Comparison of plastering work productivity

Types of Labor	Labor Productivity (m ² /Man-Day)		
	Regular	Overtime	AHSP
Foreman	21.28	27.22	303.03
Skilled labor	21.28	27.22	10.00
Unskilled labor	10.64	13.61	5.00

Note: AHSP = Analysis of Unit Price of Work, Analisis Harga Satuan Pekerjaan.

Table 8. Comparison of skim coating work productivity

Types of Labor	Labor Productivity (m ² /Man-Day)		
	Regular	Overtime	AHSP
Foreman	47.99	71.63	303.03
Skilled labor	23.99	35.82	10.00
Unskilled labor	47.99	71.63	5.00

Note: AHSP = Analysis of Unit Price of Work, Analisis Harga Satuan Pekerjaan.

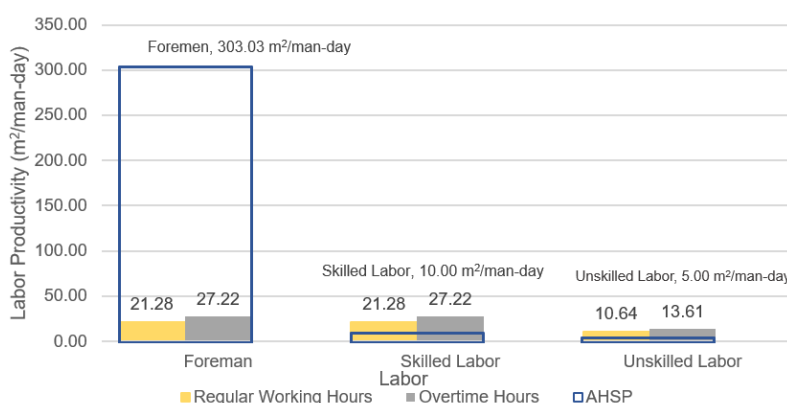


Figure 6. Comparison between on-site measured plastering productivity and the AHSP

Note: AHSP = Analysis of Unit Price of Work, Analisis Harga Satuan Pekerjaan.

This pattern suggests potential issues with labor allocation and role distribution that are common in developing country construction contexts, where optimal workforce organisation may not align with established standards [23, 37]. The findings underscore the importance of realistic productivity benchmarking that considers local construction industry characteristics while striving for continuous improvement toward national standards.

Worker productivity in plastering and rendering work is influenced by working conditions, both during regular working hours and overtime. Based on Table 6 for plastering work, labor productivity during overtime is higher than during regular working hours, with Foremen and Laborers achieving a productivity rate of 27.22 m²/OH, higher than the normal working hours productivity rate of 21.28 m²/OH. Laborers also show an increase in productivity during overtime, with a rate of 13.61 m²/OH compared to the normal rate of 10.64 m²/OH. When compared to productivity based on AHSP standards, there is a significant difference, where Foremen should have a productivity rate of 303.03 m²/OH, far exceeding that of Laborers and Laden, with productivity rates of 10.00 m²/OH and 5.00 m²/OH respectively. For a more precise comparison, refer to Figure 6.

Although labor productivity increases from regular working hours to overtime, the comparison of productivity with AHSP reveals an imbalance in the workload. The foreman's productivity, although higher during overtime compared to regular working hours, is still below the target set by AHSP, so that this condition can be categorised as underwork. Conversely, the productivity of the Craftsmen and Laborers, which also increased during overtime,

shows figures far exceeding AHSP standards, indicating a condition of overworking. This imbalance is caused by the insufficient number of workers available to meet the demands of AHSP standards. With an inadequate number of workers, the workload becomes uneven, where some workers, such as laborers and assistants, must work harder to achieve productivity targets. Meanwhile, foremen may have a less active role or may not be fully involved in the work process to their full capacity.

A similar situation occurs in plastering work, as shown in Figure 7. The productivity of Foremen and Laborers during overtime reaches the exact figure of 71.63 m²/OH, which is higher than the productivity during regular working hours, at 47.99 m²/OH. Meanwhile, the laborer also shows an increase from 23.99 m²/OH during regular working hours to 35.82 m²/OH during overtime. However, when compared to AHSP standards, the foreman's productivity is significantly higher at 303.03 m²/OH, while the laborers and assistants have standards of 10.00 m²/OH and 5.00 m²/OH, respectively.

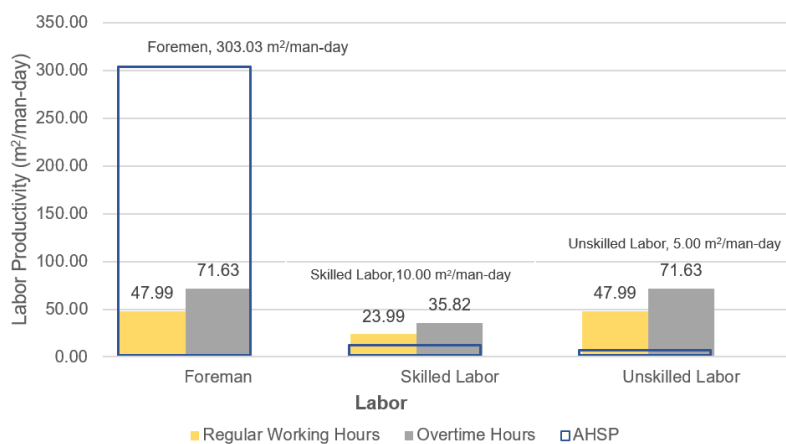


Figure 7. Comparison between on-site measured skim coat productivity and the AHSP

Note: AHSP = Analysis of Unit Price of Work, Analisis Harga Satuan Pekerjaan.

The same trend was also found in studies conducted by Putra et al. [24] and Kurniawan and Nursin [38]. In floor slab reinforcement work, the average overtime productivity was 93%, 65%, and 64% higher, respectively, for the positions of foreman, laborer, and assistant laborer. Meanwhile, in lightweight brick wall installation work, productivity increased by 185%, 32%, and 22%. The productivity achieved increased during overtime work compared to regular working hours [24].

Productivity for pile driving work during regular hours was 3,489 m/person-hours and 3,941 m/person-hours during overtime; productivity for reinforcing capping beams during regular hours is 8,610 kg/person-hours and 12,415 kg/person-hours during overtime; formwork work during regular hours is 0.462 m²/person-hours and 0.763 m²/manhours during overtime; and regular concrete pouring work is 0.170 m³/manhours [38]. To address this issue, an evaluation of the required number of workers is necessary, based on the type of work performed. Adjusting the allocation of workers and optimising the roles of each category of workers can help create more balanced and efficient working conditions, thereby aligning worker productivity with AHSP standards and minimising underwork conditions. This approach also has the potential to improve work quality and maintain the overall well-being of workers.

4.5 Statistical Validation of Productivity Differences

4.5.1 Normality testing and statistical test selection

Prior to conducting comparative statistical analysis, normality testing was performed on the productivity data to determine the appropriate analytical procedures. Tables 9 and 10 present normality test results for plastering and skim coating work productivity data using SPSS software analysis, following established protocols for construction productivity research [39, 40]. The normality test results indicate that skim coating productivity data follows standard distribution patterns ($p > 0.05$), enabling parametric statistical analysis using paired t -tests. However, plastering work data shows non-normal distribution characteristics for overtime conditions ($p < 0.05$), necessitating non-parametric statistical approaches using Wilcoxon Signed-Rank Tests, consistent with best practices in construction productivity statistical analysis [39, 40].

4.5.2 Statistical analysis results for plastering work

For productivity analysis of plastering work, Wilcoxon Signed-Rank Tests were employed due to the non-normal distribution of the data. Tables 11, 12, and 13 present the statistical analysis results for different labor categories,

showing that productivity differences between regular and overtime working hours for plastering work are not statistically significant at the $\alpha = 0.05$ significance level ($p = 0.109 > 0.05$).

This finding suggests that while observable differences exist in productivity patterns, the magnitude of change does not reach statistical significance thresholds, supporting the earlier observation that plastering work maintains relatively stable productivity during overtime periods. The results align with research indicating that repetitive construction tasks are less susceptible to productivity variation during extended working hours [8].

Table 9. Normality test results of productivity data in plastering work

Working Hours	Types of Labor	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Regular	Foreman	0.333	3	.	0.862	3	0.274
	Skilled labor	0.331	3	.	0.865	3	0.281
	Unskilled labor	0.333	3	.	0.862	3	0.274
Overtime	Foreman	0.385	3	.	0.750	3	0.000
	Skilled labor	0.385	3	.	0.750	3	0.000
	Unskilled labor	0.385	3	.	0.750	3	0.000

Note: a. Lilliefors significance correction.

Table 10. Normality test results of productivity data in skim coating work

Working Hours	Types of Labor	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Regular	Foreman	0.208	3	.	0.992	3	0.826
	Skilled labor	0.208	3	.	0.992	3	0.826
	Unskilled labor	0.202	3	.	0.994	3	0.851
Overtime	Foreman	0.228	3	.	0.982	3	0.742
	Skilled labor	0.228	3	.	0.982	3	0.742
	Unskilled labor	0.228	3	.	0.982	3	0.742

Note: a. Lilliefors significance correction.

Table 11. Wilcoxon Test–foreman (plastering)

Test Statistics ^{a,b}	Overtime-Regular
Z	−1.604 ^c
Asymp. Sig. (2-tailed)	0.109

Note: a. labor = foreman; b. Wilcoxon Signed Ranks Test; and c. based on negative ranks.

Table 12. Wilcoxon Test–skilled labor (plastering)

Test Statistics ^{a,b}	Overtime-Regular
Z	−1.604 ^c
Asymp. Sig. (2-tailed)	0.109

Note: a. labor = skilled labor; b. Wilcoxon Signed Ranks Test; c. based on negative ranks.

Table 13. Wilcoxon Test–unskilled labor (plastering)

Test Statistics ^{a,b}	Overtime-Regular
Z	−1.604 ^c
Asymp. Sig. (2-tailed)	0.109

Note: a. labor = unskilled labor; b. Wilcoxon Signed Ranks Test; c. based on negative ranks.

4.5.3 Statistical analysis results for skim coating work

For skim coating work, paired t-tests were appropriate due to the normal distribution of the data. Tables 14, 15, and 16 present the statistical analysis results for different labor categories, revealing statistically significant differences in productivity between regular and overtime working hours ($p = 0.031 < 0.05$).

The calculated t -statistic values (-5.511 and -5.572) exceed the critical t -value (4.303) at $\alpha = 0.05$ significance level, suggesting significant productivity differences between working hour conditions. These results provide preliminary statistical evidence for the negative impact of overtime work on precision-based construction activities, supporting the hypothesis that skill-intensive tasks are more vulnerable to fatigue-related productivity decline [41, 42].

Table 14. Paired t -test–foreman (skim coating)

Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
			Lower	Upper			
-3.397	1.068	0.616	-6.049	-0.745	-5.511	2	0.031

Table 15. Paired t -test–skilled labor (skim coating)

Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
			Lower	Upper			
-1.700	0.528	0.305	-3.013	-0.387	-5.572	2	0.031

Table 16. Paired t -test–unskilled labor (skim coating)

Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
			Lower	Upper			
-3.397	1.068	0.616	-6.049	-0.745	-5.511	2	0.031

5 Discussion of Findings and Industry Implications

5.1 Comparison with International Research Findings

The study results demonstrate consistency with international research on the effects of overtime work in construction, particularly the findings reported by Sonmez [15] and recent comprehensive reviews by Chang and Woo [43]. The maintenance of volume-based productivity during overtime periods, despite decreased time utilization efficiency, suggests that workers compensate for reduced efficiency through sustained effort levels, a phenomenon documented in multiple international contexts [44, 45]. Additionally, the down-payment output-based payment system observed in this project may further explain the sustained volume output during overtime, as workers had a direct financial incentive to prioritise area completion over time utilisation efficiency.

However, the Indonesian construction context presents unique characteristics that differentiate its findings from those of studies conducted in developed countries. The observed LUR values (56.94% for plastering and 66.67% for skim coating during regular hours) fall within the range reported for developing country construction projects, which typically show lower productivity levels compared to developed countries due to factors including training, technology adoption, and work organization systems [37, 46].

The differential impact between work types aligns with findings from global construction industry analyses, which indicate that construction productivity varies significantly based on task complexity and skill requirements [47]. The finding that precision work (skim coating) shows greater sensitivity to overtime effects compared to repetitive work (plastering) supports global trends in construction labor management research [48–50].

5.2 Practical Implications for Construction Management

The research findings provide several important implications for construction project management practices in developing country contexts. First, the differential impact of overtime work on different finishing activities suggests that overtime policies should be tailored to specific work types rather than applied uniformly across all construction activities. Precision work such as skim coating, which showed a 6.5% efficiency decline during overtime despite increased volume output, should not be scheduled for extended hours. Instead, project managers are advised to consider rescheduling precision finishing activities or augmenting the workforce during critical periods to maintain both quality and efficiency standards.

Second, the prevalence of waiting time and coordination delays identified in the activity analysis indicates opportunities for productivity improvement through enhanced project planning and communication systems. The 94 instances of waiting for instructions during regular hours represent approximately 7.3% of total observed activities, consistent with findings from other Indonesian construction studies [23, 51]. This finding suggests project manager to evaluate the similar repetitive tasks to identify inefficiency workflow and capturing substantial potential for productivity gains.

Third, the gap between field productivity and AHSP standards shows that more realistic benchmarks are needed, especially ones that reflect actual conditions in the local construction industry. In this study, field productivity was still below the expected standard. This may be influenced by several factors, including payment systems and worker availability. Construction managers should prioritize improvement strategies within these constraints to readjust context-specific productivity targets that reflect actual site conditions, while striving for continuous improvement toward national standards, as supported by recent Asian Development Bank analysis of Indonesian labor market challenges [24].

Fourth, the statistical validation of productivity differences provides evidence-based support for overtime work policies, enabling managers to make informed decisions about when and how to implement extended working hours. The significant productivity impact on skim coating work (a 6.5% LUR decrease) compared to the minimal impact on plastering work (a 1% LUR decrease) provides quantified guidance for work scheduling decisions. To translate these findings into practical management guidance, Table 17 synthesises the key results into a decision framework that project managers can apply when evaluating whether to implement overtime for specific finishing activities. The framework integrates LUR change, volume output change, and statistical significance into a single reference tool, with recommended actions differentiated by work type and a decision criterion based on the 5% LUR decline threshold identified in this study.

Table 17. Overtime decision framework for finishing work activities

Work Type	LUR Change (OT vs Regular)	Volume Change	Statistical Sig.	Recommended Action
Plastering (repetitive)	-1.0% (minimal)	+28%	Not sig. ($p = 0.109$)	Overtime ACCEPTABLE; monitor cumulative fatigue
Skim coating (precision)	-6.5% (substantial)	+49%	Significant ($p = 0.031$)	Overtime NOT RECOMMENDED; reschedule or add workers
Any finishing work	-	-	-	Avoid overtime when quality is the primary concern

Note: Decision criterion: If Labor Utilization Rate (LUR) decline exceeds 5% and is statistically significant, overtime should be reconsidered in favour of workforce augmentation or schedule revision. Project managers should prioritise worker welfare alongside output targets, particularly for precision-based activities.

5.3 Limitations and Future Research Directions

The statistical analysis in this study is based on a limited number of observation days; three days per work type under both regular and overtime conditions, with two observation sessions recorded per overtime day compared to four sessions during regular hours, yielding low degrees of freedom ($df = 2$) for all tests conducted. While the Wilcoxon Signed-Rank test for plastering and the paired t -test for skim coating are appropriate given the respective data distributions, the resulting p -values should be interpreted with caution. The statistically significant result for skim coating ($p = 0.031$) and the non-significant result for plastering ($p = 0.109$) are best regarded as preliminary evidence rather than firm conclusions. Future studies with larger sample sizes and extended observation periods are needed to confirm these findings with greater statistical power.

The study's scope is further limited by its focus on a single residential project site and two specific finishing activities, which may restrict the generalizability of the findings to other construction contexts. Productivity patterns in commercial or infrastructure projects, where work organisation and task complexity differ substantially, may not follow the same trends observed here.

Additionally, this study examined immediate productivity effects without investigating longer-term impacts of overtime work on worker health, job satisfaction, and sustained performance capacity. Future research should explore these broader dimensions to support holistic labor management practices in construction, particularly in developing-country contexts where worker welfare considerations may differ from those in higher-income settings.

A further contextual factor concerns the payment system in the observed project. A down-payment scheme tied to targeted output was in place, whereas AHSP standards are generally formulated based on daily wage assumptions under normal working conditions. This structural difference may influence worker behavior and output rates in ways that are not captured by the LUR metric alone. Future research comparing field productivity with AHSP

benchmarks should explicitly account for the prevailing payment structure, as it may confound direct comparisons between measured productivity and national standard.

Recommendations for future research include: (1) longitudinal studies examining the cumulative effects of overtime work over extended periods; (2) comparative studies across different project types, sizes, and contractual arrangements; (3) investigation of the impacts of technology adoption on overtime productivity relationships; (4) analysis of cultural and regional factors affecting construction productivity patterns across Southeast Asia; and (5) development of context-specific productivity improvement strategies tailored to developing-country construction industries.

The integration of advanced data collection technologies, such as IoT sensors and automated work sampling systems, could enhance the precision and scope of future productivity measurements while reducing observation costs and potential observer bias [13, 52, 53]. Such technological enhancements could enable larger-scale studies that capture productivity variations across multiple projects simultaneously, providing more robust and generalisable evidence for construction management decision-making.

6 Conclusions and Recommendations

The findings indicate that the impact of overtime work varies across different types of finishing activities. Plastering showed only a marginal reduction in productivity (approximately 1.0% decrease in LUR), whereas skim coating exhibited a more pronounced decline (around 6.5%). This pattern suggests that tasks requiring higher precision may be more sensitive to extended working hours than repetitive manual operations. Statistical analysis supports this observation, with a significant difference identified for skim coating ($p = 0.031$), while no statistically meaningful difference was observed for plastering ($p = 0.109$).

In contrast to the reduction in time efficiency, volume-based measurements show that output increased during overtime periods. Productivity gains of approximately 28% for plastering and 49% for skim coating were observed when measured in terms of completed work area. One possible explanation is the output-based payment arrangement applied in the observed project, which may have encouraged workers to prioritise task completion. Nevertheless, these improvements remain below Indonesian national benchmark levels, indicating that factors beyond working hours continue to constrain productivity. This is consistent with the observed reduction of approximately 6% in effective work activities during overtime.

The analysis of activity patterns shows that waiting for instructions was the most frequent non-productive activity, accounting for about 7.3% of total observations during regular working hours. This suggests that coordination issues contribute to productivity loss alongside the effects of extended working hours. From a management perspective, improving work planning and communication between supervisors and workers may provide a direct opportunity to reduce idle time. At the same time, although overtime increases output volume, it is associated with lower time efficiency, indicating that its use should be evaluated carefully in relation to project requirements.

Further research could extend the analysis beyond a single project setting to include different construction types and project phases. Long-term investigations into the effects of overtime on worker performance and health would provide a more comprehensive understanding of sustainable working practices. In addition, incorporating quality-related indicators into productivity assessment may help to balance schedule considerations with construction standards. Comparative studies across different regional contexts may also improve the applicability of the findings.

Author Contributions

Conceptualization, L. and M.I.R.R.; methodology, L. and M.I.R.R.; software, M.I.R.R.; validation, M.I.R.R. and W.N.; formal analysis, L. and A.; investigation, A. and M.I.R.R.; resources, M.I.R.R.; data curation, M.I.R.R. and L.; writing—original draft preparation, L.; writing—review and editing, L., A., and M.I.R.R.; visualization, M.I.R.R.; supervision, L., A., and W.N.; project administration, L.; funding acquisition, L. All authors have read and agreed to the published version of the manuscript.

Data Availability

The data used to support the research findings are available from the corresponding author upon request. The raw work sampling observation data collected in this study, including daily observation records, activity classification sheets, and statistical analysis outputs. Data were collected at a residential construction project in Palangka Raya, Indonesia, during June–December 2025. Requests for data should specify the type of data required and the intended use.

Acknowledgements

The authors are grateful to Palangka Raya University for supporting and funding this article.

Conflicts of Interest

The authors declare no conflicts of interest.

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