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RESEARCH & PUBLISHING

Priviet Social Sciences Journal

Volume 6
Issue 2 February, 2026

Article 58

27-02-2026

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To cite this article: Krisnantara, P. M. A., Indrashwara, D. C., Ariana, I. K. A., & Nuraga, I. K. (2026). Analysis of labor productivity in the installation of walls with lightweight bricks in the construction project of Sudamala Resort Ubud. *Priviet Social Sciences Journal, 6*(2), 627-638.
https://doi.org/10.55942/pssj.v6i2.1372

To link to this article: https://doi.org/10.55942/pssj.v6i2.1372

Private Social Sciences Journal
E-ISSN 2798-6314
P-ISSN 2798-866X
https://doi.org/10.55942/pssj.v6i2.1372

Volume 6
Issue 2
February Edition 2026

Analysis of labor productivity in the installation of walls with lightweight bricks in the construction project of Sudamala Resort Ubud

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Received 21 December 2025
Revised 16 February 2026
Accepted 27 February 2026

ABSTRACT

Labor productivity is an important indicator for controlling time, cost, and quality in construction projects. The installation of lightweight brick walls requires a high level of efficiency; however, in practice, there is often a discrepancy between the actual productivity in the field and applicable standards. This study aims to analyze labor productivity in lightweight brick wall installation work and compare it with the standards set out in Regulation of the Minister of Public Works and Public Housing (Permen PUPR) Number 01 of 2022. The study was conducted on the Sudamala Resort Ubud construction project using direct observation and a work sampling approach. Observations were made for 14 working days during normal working hours to obtain data on the number of workers, effective working time, and volume of work produced. The data were analyzed to determine the productivity value and coefficient of workers, which consisted of foremen, master craftsmen, craftsmen, and laborers. The results of the study show that the average productivity of workers in the field is 18.175 m^2/day for foremen, 19.123 m^2/day for master craftsmen, and 18.546 m^2/day for craftsmen and workers, with productivity coefficients of 0.055, 0.041, and 0.239, respectively. Compared to the standard of Permen PUPR 01 of 2022, there are differences in productivity values and coefficients in each labor category. These differences are influenced by the field conditions, workforce composition, and work implementation methods.

Keywords: labor productivity; lightweight bricks; work sampling; construction projects; PUPR Regulation No. 01 Of 2022.

1. INTRODUCTION

Labor productivity is widely recognized as a key determinant of time performance, cost efficiency, and quality in construction projects. Numerous empirical studies have confirmed that low labor productivity contributes significantly to project delays and cost overruns, particularly in building construction works that rely heavily on manual labor (Cahyadi et al., 2021; Putri et al., 2023). Therefore, accurate measurement and evaluation of labor productivity are essential for supporting effective construction management and decision-making.

In recent years, lightweight brick wall installation has become increasingly common in Indonesian construction projects because of its advantages in reducing structural load and accelerating construction time. However, several studies have indicated that the expected productivity improvements from lightweight bricks are not always achieved in field implementation (Saputro & Riyanto, 2021; Suryadi, 2020). Variations in labor skills, work organization, material handling, and site conditions often result in productivity levels that differ from those assumed during the planning stages (Muntaha et al., 2022).

This condition was also observed in the construction of the Sudamala Resort Ubud project in Bali, where lightweight brick walls were used extensively. Resort construction projects have unique characteristics, including limited working space, architectural complexity, and strict quality requirements, which may influence labor productivity differently than conventional building projects. Previous research emphasizes that productivity standards derived from generalized conditions may not fully capture project-specific dynamics (Maulana & Saleh, 2024; Putri et al., 2023).

From a regulatory perspective, the Indonesian government has standardized labor productivity coefficients through the Regulation of the Minister of Public Works and Public Housing Number 01 of 2022 as a basis for unit-price analysis (AHSP). While this regulation plays an important role in ensuring consistency in cost estimation, several researchers argue that standard coefficients should be continuously validated using empirical field data to remain relevant to actual construction practices (Pratiwi & Pudyastuti, 2023; Putri et al., 2023). Without such validation, discrepancies between planned and actual productivity may persist, leading to inefficiencies in labor planning and project execution.

Previous studies on labor productivity in lightweight brick wall installation have mainly focused on conventional building projects, leaving a contextual gap regarding productivity performance in hospitality or resort construction projects with distinct spatial and operational characteristics. In addition, most studies rely on standardized productivity coefficients without systematically validating them against continuous field-based observations, indicating a methodological gap in assessing the applicability of these national standards. Furthermore, inconsistent findings across studies suggest that labor productivity is highly context-dependent, highlighting a theoretical gap in understanding the boundary conditions of the existing productivity benchmarks. To address these gaps, this study contributes empirical evidence from a resort construction project in Ubud, Bali, using a work sampling approach over 14 working days, and directly compares observed productivity with the standards stipulated in the Regulation of the Minister of Public Works and Public Housing Number 01 of 2022. The findings provide a more realistic assessment of labor productivity and support more accurate labor planning and cost estimation in similar construction projects.

Labor productivity is influenced by multiple interrelated factors, including workforce composition, supervision quality, work methods, and effective working time. Empirical studies using work sampling and time study methods have demonstrated that direct observation provides reliable insights into actual labor performance and productivity fluctuations on site (Maulana & Saleh, 2024; Putri et al., 2023). Therefore, these methods are suitable for evaluating real productivity conditions and identifying gaps between normative standards and field realities.

Based on these considerations, this study aims to analyze labor productivity in lightweight brick wall installation at the Sudamala Resort Ubud construction project using a work sampling method. The observed productivity values are compared with the standards stipulated in Regulation of the Minister of Public Works and Public Housing Number 01 of 2022. This study is expected to contribute empirical evidence to the discussion on labor productivity standards and provide practical insights for improving labor planning accuracy in construction projects with similar characteristics.

2. LITERATURE REVIEW

Workforce productivity in construction projects is a key factor that determines success. The productivity characteristics include:

2.1 Construction Project

A project is a series of activities carried out within a limited timeframe using specific resources with the expectation of achieving the desired results. Achieving the objectives of a construction project involves the implementers or many parties involved (Cahyadi et al., 2021). A construction project initially consists of a sequence of continuous activities, starting from the procurement of funds to the need for resources to complete the project. In the construction world, the ability to move productively in its implementation is greatly influenced by quality, cost, and time; therefore, so that in order to obtain the desired results, the role of good human resources is very much needed (Maulana & Saleh, 2024).

2.2 Productivity

Productivity can be defined as the ratio between output and input or the ratio between production results and total resources used in a construction project. The productivity ratio is a value measured during the construction process, which can be broken down into costs, labor, materials, money, methods, and tools (Muntaha et al., 2022). The success or failure of construction depends on the effectiveness of the resource management. In the context of construction projects, labor productivity reflects not only how quickly work can be completed but also how optimally labor is used in relation to the available resources. Therefore, productivity measurement is an important indicator for assessing the performance of a team in the field and determining strategies for improving efficiency in future projects (Saputro & Riyanto, 2021).

2.3 Labor Force

Labor is a human resource that plays an important role in the construction sector because it is the main driver of production in producing goods and services. In the implementation of construction work, labor is classified into foremen, master craftsmen, craftsmen, and workers (Syahputra, 2023). Foremen are responsible for supervising work and coordination in the field, while master craftsmen play a role in organizing the division of tasks and ensuring that work is carried out in accordance with technical standards. Craftsmen are skilled workers with specific expertise in their respective fields, while laborers support construction activities through physical work and material preparation The division of labor among workers affects the effectiveness and productivity of construction work.

2.4 Labor Productivity Coefficient

In PUPR Regulation 1 of 2022, the procedure for calculating the unit price of lightweight bricks, which is adjusted to Indonesian conditions by modifying the unit price index (Pratiwi & Pudyastuti, 2023). The labor productivity coefficient for lightweight brickwork with dimensions of 60cm x 20cm x 10cm can be seen in the Table 1.

Table 1. Installation of 1m² of 10cm thick lightweight brick wall

No	Description	Code	Unit	Coefficient
1	Worker	L.01	OH	0,671
2	Carftman	L.02	OH	0,13
3	Foreman	L.03	OH	0,013
4	Supervisor	L.04	OH	0,003

2.5 Lightweight Brick

Lightweight brick also known as foamed concrete, is a material made from mortar mixed with a foam agent by controlling the foam mixture so that the density of the lightweight brick is between 5001600 kg/m3. Autoclaved Aerated Concrete (AAC) (Putra et al., 2021). Lightweight Brick AAC lightweight bricks are lightweight bricks in which the air bubble formation process is caused by a chemical reaction, namely when aluminum powder or aluminum paste expands, similar to the addition of yeast to dough in bread making. The mixture for AAC lightweight bricks generally consists of quartz sand, lime, gypsum, cement, water, and aluminum paste (Saputro & Riyanto, 2021).

2.6 Labor Productivity Measurement

Productivity can be measured by calculating the ratio of output to input, as shown in the following equation:

$$\text{Productivity} = \frac{number\ of\ workers}{volume\ of\ work\ per\ day}$$

3. METHODOLOGY

3.1. Research Design

This study uses a quantitative descriptive research design with a case study approach, which aims to analyze labor productivity in lightweight brick wall installation work. The study was conducted through direct observation in the field using the work sampling method to obtain data on working time, number of workers, and volume of work produced. The data obtained was then analyzed to determine the productivity value and labor productivity coefficient, which was then compared with the standards listed in the Regulation of the Minister of Public Works and Public Housing Number 01 of 2022.

This research framework was systematically developed, starting from problem identification, data collection through field observation, labor productivity analysis, to comparison of results with the standards of Minister of Public Works and Public Housing Regulation No. 01 of 2022 to obtain research conclusions.

3.2. Research Location and Time

In this study, the object observed was the construction of lightweight brick walls in the Entry A construction project at the Sudamala Resort Ubud project, located on Jl. Suweta, Ubud, Ubud District, Gianyar Regency, Bali. This study was conducted over a period of 14 days or 2 weeks during normal working hours, namely 08:00-17:00 WITA. Type and Source of Research Data. See Figure 1

Figure 1. Site plan for the construction of Sudamala Resort Ubud

3.3. Data Collection Techniques

The data collection technique in this study was conducted through direct observation in the field on the installation of lightweight brick walls using the work sampling method to record labor activities, effective working time, and the volume of work produced. In addition, interviews were conducted with relevant parties in the project to obtain supporting information regarding the implementation of the work. Secondary data was collected through a literature study in the form of project drawings and reference standards from the Minister of Public Works and Public Housing Regulation Number 01 of 2022 as a basis for productivity comparison.

3.4. Data Analysis Techniques

Data analysis techniques are carried out by calculating labor productivity based on a comparison between output in the form of the area of lightweight brick walls installed and input in the form of effective working time. Next, the productivity value is used to determine the productivity coefficient of each worker, consisting of foremen, master craftsmen, craftsmen, and laborers. The results of the analysis are then compared with the standard productivity coefficient listed in the Regulation of the Minister of Public Works and Public Housing Number 01 of 2022 to determine the level of conformity of labor productivity in the field.

4. RESULT AND DISCUSSION

4.1 Researh Design

This study employed a quantitative descriptive research design with a case study approach to analyze labor productivity in lightweight brick wall installation work. This design was selected to obtain an objective and systematic measurement of actual labor productivity under real construction site conditions and to compare the results with existing national productivity standards.

4.2 Unit of Analysis

The unit of analysis in this study was labor productivity, measured as the ratio between the output (area of lightweight brick wall installed in m^2) and the input (effective working time and number of workers) for each labor category, namely foreman, head craftsman, craftsman, and worker.

4.3 Research Location

The research was conducted at the Sudamala Resort Ubud construction project, located on Jl. Suweta, Ubud District, Gianyar Regency, Bali, Indonesia. This project was selected because it represents a hospitality construction project that extensively applies lightweight brick wall systems and has specific site characteristics that may influence labor productivity.

4.4 Population and Sample

The population of this study consisted of all workers involved in lightweight brick wall installation activities at the project site during the observation period. The sample included all workers directly engaged in the installation work, comprising foremen, head craftsmen, craftsmen, and laborers. A total sampling technique was applied, as the number of workers involved in the observed activities was limited and manageable, allowing all relevant labor groups to be included in the analysis. See Table 2

Table 2. Results of Observation of Lightweight Brick Wall Construction

Day	Worker				Work Volume (m^2)
	Foreman	Head Craftsman	Craftsman	Worker	
1	1	1	5	5	24,6
2	1	1	5	5	23,49
3	1	1	5	5	17,33

4	1	1	4	4	14,18
5	1	1	5	5	18,4
6	1	1	3	3	17
7	1	1	4	4	24,07
8	1	1	4	4	20,26
9	1	1	5	5	21,22
10	1	1	4	4	15,56
11	1	1	5	5	20,7
12	1	0	5	5	16,98
13	1	0	5	5	18,64
14	1	0	3	3	18,64
		Total			262,55
		Avarage			18,896

Based on direct observations of the installation of lightweight brick walls at the Sudamala Resort Ubud construction project, conducted over 14 working days during normal working hours, it was found that the average volume of work produced was 18.896 m² per day. The observations showed that work productivity fluctuated daily, influenced by the number and composition of workers, field conditions, and the smooth distribution of materials and adhesives.

4.5 Calculation of Productivity Coefficient

After obtaining data on work activity observations during one working day during normal working hours, as well as the number of workers involved, the productivity coefficient of the work group on lightweight brick wall construction can be determined. Labor productivity is calculated by comparing inputs and outputs. The relationship between the two variables can be seen through the productivity calculation formula.

$$\text{Productivity} = \frac{number\ of\ workers}{volume\ of\ work\ per\ day}$$

Calculations were made up to the 14th day with different productivity values and numbers of workers. The summary results of the above calculations can be seen in Table 3

Table 3. Calculation of Productivity Coefficient for Lightweight Brick Wall Construction

Day	Worker					Work Volume	Productivity Coeffient			
	Foreman	Head Craftsman	Craftsman	Worker	Total Workforce		Foreman	Head Craftsman	Craftsman	Worker
1	1	1	5	5	12	24,6	0,041	0,041	0,203	0,203
2	1	1	5	5	12	23,49	0,043	0,043	0,213	0,213
3	1	1	5	5	12	17,33	0,058	0,058	0,289	0,289
4	1	1	4	4	10	14,18	0,071	0,071	0,282	0,282
5	1	1	5	5	12	18,4	0,054	0,054	0,272	0,272

6	1	1	3	3	8	17	0,059	0,059	0,176	0,176
7	1	1	4	4	10	24,07	0,042	0,042	0,166	0,166
8	1	1	4	4	10	20,26	0,049	0,049	0,197	0,197
9	1	1	5	5	12	21,22	0,047	0,047	0,236	0,236
10	1	1	4	4	10	15,56	0,064	0,064	0,257	0,257
11	1	1	5	5	12	20,7	0,048	0,048	0,242	0,242
12	1	0	5	5	11	16,98	0,059	0,000	0,294	0,294
13	1	0	5	5	11	18,64	0,054	0,000	0,268	0,268
14	1	0	3	3	7	12,12	0,083	0,000	0,248	0,248
		Total				264,55	0,770	0,575	3,343	3,343
		Avarage				18,896	0,055	0,041	0,239	0,239

From the Table 3, we can see the average productivity coefficient values for each worker: for foremen, it is 0.055 OH; for master craftsmen, it is 0.041 OH; for craftsmen, it is 0.239 OH; and for workers, it is 0.239 OH. Furthermore, this is compared with the Regulation of the Minister of Public Works and Public Housing Number 01 of 2022 that has been stipulated.

4.6 Comparison with Ministry of Public Works and Public Housing Regulation No. 1 of 2022

After obtaining the productivity coefficient value for lightweight brick wall construction in the field, it can be compared with the productivity coefficient from Regulation of the Minister of Public Works and Public Housing Number 01 of 2022. Table 4 is productivity coefficient values from Permen PUPR 01-2022.

Table 4. Public Works and Public Housing Regulation No. 1 of 2022 Public Housing Regulation No. 1 of 2022

Description	Code	Unit	Coefficient
Worker	L.01	OH	0,671
Craftsman	L.02	OH	0,13
Head Craftsman	L.03	OH	0,013
Foreman	L.04	OH	0,003

After obtaining the coefficient values from Regulation of the Minister of Public Works and Public Housing Number 01 of 2022, we then compared the productivity coefficient values in Regulation of the Minister of Public Works and Public Housing Number 01 of 2022 with the coefficient values observed in the field. The following is a table comparing the productivity coefficient values from Permen PUPR 012022 with the results of field observations.

Table 5. Comparison of Productivity Coefficients

Worker	Unit	Productivity Coeffcient		Difference
		PUPR 01-2022	Observation Results	
Foreman	OH	0,003	0,055	-0,052
Head Craftsman	OH	0,013	0,041	-0,028
Craftsman	OH	0,13	0,239	-0,109
Worker	OH	0,617	0,239	0,378

As can be seen in Table 5, the productivity coefficient values for the work groups of foremen, master craftsmen, craftsmen, and assistant craftsmen are 0.055, 0.041, 0.239, and 0.239, respectively. Meanwhile, the coefficient values in Permen PUPR 01-2022 are for foremen 0.003; master craftsmen 0.013; craftsmen 0.186; and workers 0.143. The difference in productivity coefficients for foremen is 0.052 OH, for master craftsmen is -0.028 OH, for craftsmen is -0.109, and for assistant craftsmen is 0.378 OH.

4.7 Calculation of productivity value

After obtaining a comparison of the coefficient values between field observations and Regulation of the Minister of Public Works and Public Housing Number 01 of 2022, we then proceeded to calculate the productivity value from the field observation data using Regulation of the Minister of Public Works and Public Housing Number 01 of 2022, with the unit obtained being m2/day. To see the productivity value from the comparison of the productivity coefficient of Regulation of the Minister of Public Works and Public Housing Number 01 of 2022 with the results of field observations.

The productivity calculations from PUPR Regulation 01-2022 can be seen in Table 6 and Table 7

Table 6. Recapitulation of Productivity of PUPR Regulation 01-2022

Day	Worker					Productivity Coeffient			
	Foreman	Head Craftsman	Craftsman	Worker	Total Workforce	Foreman	Head Craftsman	Craftsman	Worker
1	1	1	5	5	12	333,333	76,923	38,462	8,104
2	1	1	5	5	12	333,333	76,923	38,462	8,104
3	1	1	5	5	12	333,333	76,923	38,462	8,104
4	1	1	4	4	10	333,333	76,923	30,769	6,483
5	1	1	5	5	12	333,333	76,923	38,462	8,104
6	1	1	3	3	8	333,333	76,923	23,077	4,862
7	1	1	4	4	10	333,333	76,923	30,769	6,483
8	1	1	4	4	10	333,333	76,923	30,769	6,483
9	1	1	5	5	12	333,333	76,923	38,462	8,104
10	1	1	4	4	10	333,333	76,923	30,769	6,483

11	1	1	5	5	12	333,333	76,923	38,462	8,104
12	1	0	5	5	11	333,333	0,000	38,462	8,104
13	1	0	5	5	11	333,333	0,000	38,462	8,104
14	1	0	3	3	7	333,333	0,000	23,077	4,862
		Total				4666,667	846,154	476,923	100,486
		Avarage				333,333	60,440	34,066	7,178

Public Works and Public Housing No. 01 of 2022 for foremen is 333.333 m²/day, for master craftsmen is 60.44 m²/day, for craftsmen is 34.066 m²/day, and for assistant craftsmen is 7.178 m/day.

Table 7. Recap of Observation Productivity Results

Day		**Worker**				**Productivity Coeffient**			
	Foreman	**Head Craftsman**	**Craftsman**	**Worker**	**Total Workforce**	**Foreman**	**Head Craftsman**	**Craftsman**	**Worker**
1	1	1	5	5	12	18,175	24,338	20,939	20,939
2	1	1	5	5	12	18,175	24,338	20,939	20,939
3	1	1	5	5	12	18,175	24,338	20,939	20,939
4	1	1	4	4	10	18,175	24,338	16,751	16,751
5	1	1	5	5	12	18,175	24,338	20,939	20,939
6	1	1	3	3	8	18,175	24,338	12,564	12,564
7	1	1	4	4	10	18,175	24,338	16,751	16,751
8	1	1	4	4	10	18,175	24,338	16,751	16,751
9	1	1	5	5	12	18,175	24,338	20,939	20,939
10	1	1	4	4	10	18,175	24,338	16,751	16,751
11	1	1	5	5	12	18,175	24,338	20,939	20,939
12	1	0	5	5	11	18,175	0,000	20,939	20,939
13	1	0	5	5	11	18,175	0,000	20,939	20,939
14	1	0	3	3	7	18,175	0,000	12,564	12,564
		Total				254,455	267,722	259,646	259,646
		Avarage				18,175	19,123	18,546	18,546

Based on observations from the Sudamala Resort Ubud construction project, the daily output for foremen was 18,175 m², for master craftsmen was 19,123 m², for craftsmen was 18,546 m², and for laborers was 18,546 m².

For a clearer comparison of the productivity of Minister of Public Works and Public Housing Regulation No. 01-2022 with the observations made at the Sudamala Resort Ubud construction project, please refer to the summary analysis Table 8.

Table 8. Recapitulation of Productivity Difference Calculations

Worker	**Unit**	**Productivity**		**Difference**
		PUPR 01-2022	Observation Results	
Foreman	m²/hari	333,333	18,175	315,158

Head Craftsman	m^2/hari	60,440	19,123	41,317
Craftsman	m^2/hari	34,066	18,546	15,520
Worker	m^2/hari	7,178	18,546	-11,369

5. CONCLUSION

From the results of data analysis conducted in this study, the average labor productivity values obtained were 18.175 m2/day for foremen, 19.123 m2/day for master craftsmen, 18.546 m2/day for craftsmen, and 18.546 m2/day for workers. The coefficients for each type of worker were 0.055 for foremen, 0.041 for master craftsmen, 0.239 for craftsmen, and 0.239 for laborers.

From the comparison of the productivity values of lightweight brick wall pairs conducted in the Sudamala Resort Ubud construction project, the productivity calculations obtained in accordance with Regulation of the Minister of Public Works and Public Housing Number 01 of 2022 are 333.333 m2/day for foremen, 60.440 m2/day for the foreman, 34.066 m2/day for the craftsman, and 7.178 m2/day for the worker. Furthermore, the productivity results in the field were 18.175 m2/day for foremen, 19.1223 m2/day for master craftsmen, 18.546 m2/day for craftsmen, and 18.546 m2/day for workers. The difference obtained is 315.158 m2/day for foremen, 41.317 m2/day for master craftsmen, 15.520 m2/day for craftsmen, and -11.369 m2/day for workers. A negative result means that productivity in the field is greater than that specified in PUPR Regulation 01-2022, while a positive result indicates that productivity in the field is lower than that specified in PUPR Regulation 01-2022.

Ethical Approval

Ethical approval was not required for this study because the method used was direct observation in the field of the activities and performance of workers installing lightweight brick walls, without involving the collection of personal data or sensitive information. All stages of the study were conducted in accordance with applicable research ethics rules and standards.

Informed Consent Statement

Informed consent was not required for this study because no personal data was collected from workers. The data collected was limited to the number of workers, working hours, and the volume of lightweight brick wall installation work observed at the project site.

Author's Contribution

Conceptualization and methodology, P.M.A.K. and D.C.I; validation and supervision, I.K.A.A and I.K.N; original draft writing, P.M.A.K; writing, review, and editing, P.M.A.K, D.C.I, and I.K.A.A. All authors approved the final manuscript.

Disclosure statement

The authors declare no conflict of interest related to this study.

Data Availability Statement

All data supporting this study are available from the corresponding author upon reasonable request.

Funding

This research received no external funding and was fully supported by the authors' academic affiliation.

Notes on Contributors

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Pande Made Agus Krisnantara is a student in the Civil Engineering Study Program at Universitas Pendidikan Nasional who is interested in construction management, particularly the analysis of labor productivity in construction projects. He actively develops his understanding of methods for measuring productivity, work efficiency, and the application of technical standards in building projects.

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