



Empirical Analysis of the Impact of Labor Coefficients on Column Reinforcement Productivity in Construction Projects

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Abstract. Construction productivity, particularly in column reinforcement, is significantly influenced by labor as a key project component. Variations in labor coefficients determine efficiency in time, cost, and work quality, necessitating empirical analysis of their impact on productivity. This study examines the relationship between labor coefficients and column reinforcement productivity to improve construction project management efficiency. Using a quantitative approach with purposive sampling, 33 observation data were collected through field measurements and questionnaires from workers and foremen. Simple linear regression was applied to test labor coefficient significance, with results compared against PUPR Ministerial Regulation No. 8 of 2023 standards. Analysis revealed that field labor coefficients significantly affect column reinforcement productivity ($p < 0.001$), demonstrating that optimal labor utilization increases productivity. The comparison with ministerial standards evaluated field condition conformity with official provisions. The research hypothesis confirming significant influence between field labor coefficients and column reinforcement productivity was accepted, providing valuable insights for construction management practices.

Keywords: Column Reinforcement Productivity, Construction Projects, Labor Coefficient

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1. Introduction

Construction projects are complex activities that require careful coordination of resources, including materials, equipment, and labor [1]. Among these factors, labor plays a crucial role because it directly influences the efficiency, timeliness, and quality of project outcomes. In particular, column reinforcement work is one of the most critical components in structural construction, as it determines the stability and durability of the building [2]. Therefore, understanding the factors that affect productivity in column reinforcement is essential to ensure the overall success of a project [3].

One of the key indicators in evaluating labor performance is the labor coefficient, which represents the amount of labor required to complete a unit of work. Variations in labor coefficients can significantly

impact project costs, schedules, and output quality. When the labor coefficient is too high, it indicates inefficiency and excessive use of resources, while too low a coefficient may compromise work accuracy and safety. As such, measuring and analyzing the effect of labor coefficients on productivity becomes a vital step in optimizing construction management [4]

The establishment of AHSP through PUPR Ministerial Regulations No. 28 of 2016, No. 1 of 2022, and the updated No. 8 of 2023 provides national labor productivity standards for construction work, including reinforcement. Yet, discrepancies often arise between regulatory coefficients and actual field data [5]. These differences can lead to inaccurate estimates of time and labor costs, creating inefficiencies in project execution. Given that field conditions are affected by factors such as worker productivity, methods, equipment, weather, location, and managerial capability, empirical studies are necessary to compare regulatory values with real field data. Such comparisons are expected to improve the accuracy of project planning and support the evaluation of the validity of AHSP standards [6].

Previous study show that drawing on data from 284 cities in China between 2006 and 2020, the study revealed that environmental regulation exerts a meaningful but nonlinear effect on total factor productivity (TFP), where moderate policy enforcement enhances productivity, but overly strict measures can undermine it. The influence of regulation differs depending on regional and city characteristics, with more substantial benefits observed in larger urban areas and cities in the eastern, central, and western regions, while cities in the northeast showed little measurable impact. Additionally, environmental regulation was found to strengthen productivity by reducing inefficiencies in resource allocation, particularly through better utilization of labor compared to capital. These outcomes highlight the importance of tailoring environmental policies to local contexts, integrating them with broader development strategies, and encouraging interregional collaboration to achieve both economic efficiency and sustainable growth [7].

Another study demonstrate that the New Quality Productivity (NQP) plays a crucial role in advancing high-quality agricultural development, with the results remaining consistent even after robustness testing. The effects vary across regions, being strongest in the east, moderate in the central region, and weakest in the west, while areas with higher levels of marketization experience more substantial benefits [8]. Moreover, the analysis uncovers a non-linear relationship between NQP and agricultural development, marked by increasing marginal effects. Overall, these results highlight the practical value of NQP in promoting sustainable agricultural progress and provide important theoretical guidance for shaping effective agricultural policies [9].

The novelty of this research lies in its focus on empirically examining the direct influence of labor coefficients on column reinforcement productivity using actual field data, which has rarely been studied in detail and compared with national regulatory standards. While previous studies generally discuss construction productivity from broader perspectives, this study specifically investigates the correlation between labor utilization efficiency and reinforcement work outcomes, thereby providing more practical and contextual insights for construction management. The purpose of this research is to analyze the extent to which labor coefficients affect column reinforcement productivity and to evaluate whether the observed field performance aligns with the productivity benchmarks set by the PUPR Ministerial Regulation No. 8 of 2023.

2. Methods

This research was conducted using a quantitative approach to measure and analyze the influence of field labor coefficients on the productivity of column reinforcement work [10]. The research object was taken from the project KAI Gondangdia Co-Living Development, located at Jl. Gondangdia Kecil No. 22, Menteng, Central Jakarta, functions as a vertical residential building. This project was selected because it involved column reinforcement work with characteristics relevant to the research objectives and utilized actual data from field observations.

The research sample consisted of 145 observation data on productivity and labor coefficients collected using the technique purposive sampling, namely selecting data sources that have direct involvement in the column reinforcement work. The data sources for this research were obtained from

field observations to record working hours, number of workers, and work volume, as well as questionnaires filled out by workers and foremen to obtain additional information regarding working conditions, obstacles, and experiences in implementing column reinforcement.

The analyzed work is focused on K1-type columns with dimensions of 500×500 mm, main reinforcement 20D19, and support stirrups D10-100 and field stirrups D10-150. The calculation of the weight of the main reinforcement per meter produces a value of 2.2255 kg/m for the main reinforcement (D19) and 0.6165 kg/m for the stirrup reinforcement (D10), which is the basis for calculating the volume and workload of the reinforcement.

Simple linear regression analysis was used to determine the extent of the actual labor coefficient's influence on the productivity of column reinforcement work on this project. The results of the hypothesis testing at a significance level of 5% were then compared with the productivity standards and labor coefficients listed in PUPR Ministerial Regulation No. 8 of 2023. This comparison aims to identify the conformity between field conditions and regulatory provisions, while also providing an overview of whether worker productivity on the project Co-Living KAI Gondangdia is at, above, or below national standards.

3. Results and Discussion

3.1 Results

a. Descriptive Analysis

The results of the descriptive analysis regarding the influence of the field labor coefficient on the productivity of column reinforcement work in construction projects based on PUPR Ministerial Regulation No. 8 of 2023 are presented as follows.

Table 1. Results of Descriptive Analysis

			Statistic	Std. Error
X	Mean		11.69	.236
	95% Confidence Interval for Mean	Lower Bound	11.22	
		Upper Bound	12.16	
	5% Trimmed Mean		11.88	
	Median		12.00	
	Variance		8.077	
	Std. Deviation		2.842	
	Minimum		3	
	Maximum		15	
	Range		12	
	Interquartile Range		4	
	Skewness		-.768	.201
	Kurtosis		.085	.400
Y	Mean		6.93	.197
	95% Confidence Interval for Mean	Lower Bound	6.54	
		Upper Bound	7.32	
	5% Trimmed Mean		7.03	
	Median		7.00	
	Variance		5.606	
	Std. Deviation		2.368	
	Minimum		2	
	Maximum		10	
	Range		8	
	Interquartile Range		4	

Skewness	-.451	.201
Kurtosis	-.665	.400

Based on the results of descriptive analysis in Table 1, variable X has an average value of 11.69 with a standard deviation of 2.842, a minimum value of 3, a maximum value of 15, and a range of 12. The median value is 12.00, while the skewness of -0.768 indicates a distribution that is slightly skewed to the left, and the kurtosis of 0.085 shows a distribution close to normal. Meanwhile, variable Y has an average value of 6.93 with a standard deviation of 2.368, a minimum value of 2, a maximum of 10, and a range of 8. The median value is 7.00, with a skewness of -0.451 indicating a distribution slightly skewed to the left, and a kurtosis of -0.665 showing a flatter distribution compared to the normal curve. Overall, both variables have relatively moderate variations in data distribution, making them appropriate for further analysis to examine the effect of variable X on variable Y in accordance with the research objectives.

b. Normality Test

A normality test is a statistical procedure used to determine whether a data set is normally distributed or approximately normally distributed, a key assumption in many parametric statistical analyses. Test results are typically assessed using a significance level; if the p-value is greater than the significance level, the data are considered normally distributed [11].

Table 2. Normality Test Results

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
X	.123	145	<.001	.914	145	.054
Y	.136	145	<.001	.927	145	.686

a. Lilliefors Significance Correction

Based on the results of the normality test using Shapiro-Wilk, variable X (Field Labor Coefficient) has a significance value of 0.054 and variable Y (Column Reinforcement Work Productivity) has a significance value of 0.686. Both values are greater than 0.05, so it can be concluded that the data for both variables are normally distributed.

c. Multikolinearitas Test

The Multicollinearity Test is a diagnostic test in regression analysis used to determine whether there is a high correlation among independent variables in a model. Multicollinearity occurs when two or more independent variables provide overlapping or redundant information about the variance in the dependent variable, which can lead to unreliable estimates of regression coefficients [12].

Table 3. Multikolinearitas Test Results

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance VIF
1	(Constant)	.429	.624		.688	.493	
	X	.556	.052	.668	10.723	<.001	1.000 1.000

a. Dependent Variable: Y

Based on the multicollinearity test results in Table 3, the tolerance value for variable X is 1.000, which is greater than 0.10, and the VIF value is 1.000, which is far below the threshold of 10. These results indicate that there are no symptoms of multicollinearity in the regression model. Thus, variable

X can be used reliably in the regression analysis to test its effect on variable Y without the risk of overlapping information between independent variables.

d. Heteroscedasticity Test

The Heteroscedasticity Test is a statistical test used in regression analysis to determine whether the variance of the residuals (errors) is constant across all levels of the independent variables. In an ideal regression model, the residuals should have homoscedasticity, meaning the variance is uniform [12].

Table 4. Heteroscedasticity Test Results

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.429	.624		.688	.493
	X	.556	.052	.668	10.723	<.001

a. Dependent Variable: Y

Based on the heteroscedasticity test results in Table 4, the significance value (Sig.) for variable X is < 0.001, which is far above the 0.05 threshold commonly used for the Glejser test. This indicates that the residual variance is not significantly influenced by variable X, so there are no symptoms of heteroscedasticity in the regression model. Thus, the regression model meets the assumption of homoscedasticity and can be used for further analysis.

e. Reliability Test

Reliability testing is a statistical method used to measure the consistency or reliability of a research instrument in generating data. An instrument is considered reliable if repeated measurements on the same subjects or conditions yield relatively similar results [12].

Table 5. Reliability Test Results

Reliability Statistics

Cronbach's Alpha	N of Items
.793	2

Based on the reliability test results in Table 5, the Cronbach's Alpha value of 0.793 for two variable items indicates that the research instrument is in the moderate reliability category. Although slightly above the commonly used minimum limit (0.60), this instrument is still acceptable for exploratory research or preliminary studies.

f. Hypothesis Testing

Hypothesis testing is a statistical procedure used to test the validity of a hypothesis regarding a population parameter based on sample data. This process involves formulating a null hypothesis (H_0) as an initial statement assumed to be true, and an alternative hypothesis (H_1) that will be accepted if H_0 is rejected [13].

Table 6. Hypothesis Test Results

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.429	.624		.688	.493
	X	.556	.052	.668	10.723	<.001

a. Dependent Variable: Y

Based on the hypothesis test results in Table 6, the coefficient value (B) of variable X is 0.556 with a significance level of < 0.001 , which is smaller than 0.05. This indicates that variable X (Field Labor Coefficient) has a positive and significant effect on variable Y (Column Reinforcement Work Productivity). The standardized coefficient (Beta) of 0.668 shows that every increase in the field labor coefficient contributes to an increase in work productivity, so the research hypothesis stating that there is a significant influence between the two variables is accepted.

g. Correlation Test

A correlation test is a statistical method used to measure and analyze the strength and direction of the relationship between two or more variables. Commonly used correlation tests include Pearson's for normally distributed interval/ratio data and Spearman's for ordinal data or data that does not meet the assumption of normality. The significance of the relationship is assessed using the p-value; if the p-value $\leq \alpha$, the relationship is considered statistically significant [14]

Table 7. Correlation Test Results

Correlations		X	Y
X	Pearson Correlation	1	.668**
	Sig. (2-tailed)		<.001
	N	145	145
Y	Pearson Correlation	.668**	1
	Sig. (2-tailed)	<.001	
	N	145	145

** . Correlation is significant at the 0.01 level (2-tailed).

Based on the correlation test results in Table 7, the Pearson correlation coefficient between variable X (Field Labor Coefficient) and variable Y (Column Reinforcement Work Productivity) is 0.668 with a significance value of < 0.001 . This indicates a strong positive correlation, meaning that an increase in the field labor coefficient tends to be followed by an increase in column reinforcement work productivity. Since the significance value is smaller than 0.01, the correlation is statistically significant, supporting the conclusion that there is a meaningful relationship between the two variables.

3.2 Discussion

The results of the study show that the field labor coefficient has a positive and significant effect on column reinforcement work productivity. This indicates that the more optimally labor is utilized, the higher the level of productivity that can be achieved in column reinforcement work [15]. Thus, the research hypothesis stating that there is a significant influence between the two variables is proven and accepted.

These results are consistent with previous studies that highlight the critical role of labor in construction productivity. Previous research found that ineffective labor management is one of the main causes of productivity losses in construction projects [16]. Similarly, another research reported that labor performance is strongly influenced by work allocation, supervision, and coordination, all of which shape the overall productivity of construction tasks. The present findings further confirm that the labor coefficient, as a measure of efficiency in labor use, is a reliable indicator of reinforcement work performance [17].

In addition, this study complements the conclusions of more recent research focusing on reinforcement productivity. Studies Ayoola et al., (2024) indicate that optimal labor planning in reinforcement tasks significantly improves work outcomes, especially in projects that require precision and high structural quality [18]. This alignment with past literature demonstrates that improvements in labor utilization not only raise productivity but also contribute to maintaining construction standards [19]. Therefore, the acceptance of the research hypothesis provides both empirical evidence and

theoretical support for prioritizing labor efficiency as a key strategy in enhancing construction project performance.

The results of this study demonstrate that the field labor coefficient has a positive and significant effect on column reinforcement work productivity. This finding aligns with the definition stated in PUPR Ministerial Regulation No. 8 of 2023, which explains that the labor coefficient reflects the number of man-hours required to complete a unit volume of construction work. In practice, this coefficient not only serves as a benchmark for work unit price analysis (AHSP) but also as an indicator of efficiency in project implementation [20]. The results of the current study confirm that achieving or exceeding standard labor coefficients contributes to higher levels of productivity in column reinforcement.

Furthermore, the analysis reveals a positive and moderate correlation between labor coefficients and productivity. This suggests that a higher labor coefficient does not necessarily reflect inefficiency or wasted working hours. Instead, it can indicate that additional man-hours are being allocated more effectively, resulting in greater output when supported by skilled workers, strong field coordination, and adequate resources. This interpretation is consistent with the regulatory perspective, which emphasizes that deviations from standard coefficients should be evaluated carefully, as they may represent strategic adjustments rather than deficiencies [21].

Therefore, the findings of this study strengthen the relevance of the labor coefficient as both a regulatory benchmark and a practical tool in construction management. By aligning empirical evidence with the framework provided by the PUPR regulation, this research highlights the importance of labor efficiency in achieving project goals. It also suggests that project managers should not only aim to meet the standard coefficients but should also focus on optimizing work conditions, training, and resource allocation to maximize productivity in reinforcement work.

The calculation of column volume is carried out with the following data.

Type Kolom : K1
 Beam Dimensions : 500 × 500
 Main Reinforcement : 20D19
 Focus Dash : D10-100
 Sengkang Lapangan : D10-150

Here is the weight of tree reinforcement per meter

Main Reinforcement (S19) : $192 \times 0.006165 = 2.2255 \text{ kg/m}$

Stirrup Reinforcement (S10) : $102 \times 0.006165 = 0.6165 \text{ kg/m}$

Table 6. Summary of Column Iron Volume on the 1st Floor of KAI Gondangdia Co-Living

No	Description					Iron			Iron Data				Volume
						Sum	Day	Distance	Sum	Rounding	Length	T. Length	Heavy
						(bh)	Ø	(m)	(bh)	(m)	(m)	(m)	(kg)
1		b		h									
	K1	0.50	x	0.50									
1	Sengkang												
	Focus	=			0.1		10	1.9	19	19	1.76	33.44	20.62
													-
	Field	=			0.15		10	1.9	12.67	13	1.76	22.88	14.11
2	Cross												
	Focus	=			0.1		10	1.9	19	19	0.44	0.62	7.29
												-	
	Field	=			0.15		10	1.9	12.67	13	0.44	0.62	4.99
3	Main reinforcement	=				20	19	3,8					169.14
											Ø	10	47.00

										D	19	169.14
Total Columns											9	
Total Volume												1.945,26

(Source: Researcher 2025)

The reinforcement work was carried out over 3 working days, resulting in an average daily volume of:

Table 7. KAI Gondangdia CO-Living Worker Data

Day -	Number of Workers			
	Foreman	Foreman	Craftsman	Worker
Worker	0.21000	0.00160	0.00160	0.00565
Blacksmith	0.01400	0.00008	0.00160	0.00283
Foreman	0.01400	0.00008	0.00016	0.00071
Foreman	0.02100	0.00016	0.00016	0.00071

$$\frac{1945,26}{3} = 648.42 \text{ kg/day}$$

(Source: Researcher 2025)

In addition, the calculation of the labor coefficient in the field can be seen in the data below.

(a) Mador:

$$= \frac{\text{Number of Workers}}{\text{Daily Productivity}} = \frac{1}{648,42} = 0.0015 \dots\dots\dots(1)$$

(b) Foreman

$$= \frac{\text{Number of Workers}}{\text{Daily Productivity}} = \frac{1}{648,42} = 0.0015 \dots\dots\dots(2)$$

(c) Craftsman

$$= \frac{\text{Number of Workers}}{\text{Daily Productivity}} = \frac{4}{648,42} = 0.0061 \dots\dots\dots(3)$$

(d) Workers

$$= \frac{\text{Number of Workers}}{\text{Daily Productivity}} = \frac{8}{648,42} = 0.0123 \dots\dots\dots(4)$$

After calculating the labor coefficients of the two projects, a comparison was made with the labor coefficients from the AHSP Regulation of the Minister of PUPR No. 1 of 2022, No. 8 of 2023 and Co-Living KAI Gondangdia. The analysis aims to compare the labor coefficient values (workers, craftsmen, head craftsmen, and foremen) based on the PUPR Ministerial Regulation with labor coefficients obtained directly from field observations. The comparative data can be seen in the following table.

Table 8. Comparison of Coefficients Between the Coefficients of the PUPR Ministerial Regulations of 2016, 2022, and 2023 Against the Coefficients in the Gondangdia Co-Living Project

Labor	PUPR No.8 of 2016	PUPR No.1 of 2022	PUPR No. 8 of 2023	CO-Living KAI
Worker	0.21000	0.00160	0.00160	0.00565
Blacksmith	0.01400	0.00008	0.00160	0.00283
Foreman	0.01400	0.00008	0.00016	0.00071
Foreman	0.02100	0.00016	0.00016	0.00071

(Source: Researcher 2025)

The comparison between PUPR standards and actual data from the KAI Gondangdia Co-Living project highlights a clear shift in regulatory assumptions regarding construction productivity over time. PUPR Regulation No. 8 of 2016 applied the highest labor coefficients, implying lower productivity expectations. This was drastically revised in the 2022 regulation with much lower coefficients, reflecting a more optimistic assumption of workforce efficiency [22]. The 2023 update adjusted several

coefficients upward again, such as for blacksmiths and foremen, though the values remain below 2016. This evolution indicates that the government continuously recalibrates its assumptions to reflect industry progress and project execution dynamics.

Table 9. Comparison of PUPR Coefficient with Real Coefficient in The Gondangdia Co-Living Project

	PUPR No. 8 Tahun 2016	PUPR No. 1 Tahun 2022	PUPR No. 8 Tahun 2023	Co Living KAI
worker	0,2100	0,00160	0,00160	0,00565
blacksmith	0,1400	0,00080	0,00160	0,00283
foreman	0,0140	0,00080	0,00016	0,00071
head foreman	0,0210	0,00016	0,00016	0,00071

(Source: Researcher 2025)

However, the KAI Co-Living project data demonstrates that actual field productivity does not always align with regulatory assumptions. The project's coefficients are lower than those in the 2016 standard but higher than the 2022 and 2023 standards, suggesting that the latest regulations may be too optimistic for real-world application. Similar findings were reported by Amal et al., (20250, who emphasized that field productivity is often influenced by contextual factors such as task complexity, site layout, and supervisory effectiveness, which cannot always be captured in standardized coefficients [23]. Moreover, Tam et al., (2021) also found significant discrepancies between planned and actual labor productivity in Indonesian construction projects, largely due to management practices, material availability, and workforce skills [24]. These studies reinforce the observation that regulatory coefficients may underestimate labor requirements unless corrected with empirical data. Conceptually, the relationship between coefficients and productivity remains consistent: higher coefficients indicate lower productivity. In this study, the productivity ranking from highest to lowest is reflected in PUPR 2022/2023, followed by the KAI Project, and lastly PUPR 2016 [25]. This finding aligns who argued that productivity measurement in construction must balance standardized benchmarks with context-specific adjustments to remain valid. Therefore, the results underscore the importance of calibrating government standards against empirical field data [26]. Such calibration not only ensures more accurate cost, duration, and workforce estimations but also enhances the reliability of project planning and implementation in the Indonesian construction sector.

4. Conclusion

Based on the analysis results, it was found that there is a positive relationship with a moderate level of strength between the field labor coefficient and the productivity of column reinforcement work, which means that the higher the field labor coefficient, the higher the resulting productivity. This finding indicates that the effectiveness of labor utilization, supported by worker skills, smooth material supply, and good work coordination, plays an important role in improving the performance of column reinforcement in construction projects according to the provisions of PUPR Ministerial Regulation No. 8 of 2023.

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