Jurnal Ilmu Teknik Vol. 1, No. 4 Juli 2024, Hal. 156-162
DOI: https://doi.org/10.62017/tektonik

Waste Level and Cost Analysis of Steel Reinforcement Work in Construction Projects

Aditya Pradana *[1]
I Nyoman Dita Pahang Putra [2]

[1,2] Civil Engineering Department, Faculty of Engineering and Science, Pembangunan Nasional "Veteran" University East Java, Indonesia
*e-mail: apradana317@gmail.com[1], putra_indp.ts@upnjatim.ac.id[2]

Abstract

The development of human needs in an area impacts increasing development in the construction industry sector. One of the problems that cannot be avoided from construction projects is the waste material generated during construction work. It is important to manage construction project waste properly to minimize the impact caused. Therefore, it is necessary to study the magnitude of the impact carried out in construction projects. This study aims to calculate the amount of waste level and cost of one of the construction wastes, namely reinforcing steel. The method used is a quantitative approach with the help of Microsoft Excel software. Shop Drawing is used as reference data in modeling the reinforcement shape and the purchase volume of reinforcing steel to determine the waste level and cost of steel reinforcement work planning. The results obtained are the percentage of waste level in the reviewed project of 10.15% and the percentage of waste cost of 7.39% of the total contract with a nominal waste cost of IDR 430,323,622. The percentage of waste level in this project is similar to several previous reference projects, which ranged from 4% to 13%.

Keywords: *reinforcing steel, waste cost, waste level*

INTRODUCTION

Construction development projects in an area are temporary, meaning they have a clear start and finish time. All construction developments must pay attention to quality, budget, and time. In addition, resource management must be applied optimally. In construction projects, these resources include manpower, machines, materials, money, and methods (Widiasanti & Lenggogeni, 2013). One of the problems that cannot be avoided from construction projects is waste material in the form of solid or liquid waste generated during construction work (Kareem & Pandey, 2013).

The use of materials in a construction project is often found to have a large amount of residual material waste, so efforts are needed to minimize material waste (Gavilan & Bernold, 1994). Construction waste impacts the surrounding environment during construction or demolition work (Putra, 2020). Waste management involves reduce, recycle, and reuse waste before it can be disposed of in landfills. (Widhiawati et al., 2019). It is important to manage waste properly to minimize the impact of the waste generated. In some areas, all or part of the waste needs to be handled correctly, causing pollution and harming human health. However, good material planning and control can reduce construction project waste. Such planning and control can include procuring and storing materials on-site to avoid the negative impacts of material shortages or excess materials. (Kareem & Pandey, 2013).

Based on previous research on a Hotel Building construction project in Bali using a quantitative approach with the help of Microsoft Excell to obtain reinforcing steel requirements according to the drawings on the Shop Drawing. The results obtained in the study were that the waste of reinforcing steel material was 7% (Yuni et al., 2023). Research conducted on the SDN 3 Peguyangan Building project aims to calculate waste levels and costs and use cutting optimization pro software to optimally minimize reinforcing steel waste in the project. The results of the comparison with conventional methods obtained by cutting optimization pro software can optimally minimize waste by 4% (Muka et al., 2020). Research conducted on the Kampung Dalam Health Center 3-Storey Building construction project using the linear programming. The results obtained in this study are that the waste of reinforcing steel material is 13.49% (Atmaja et al.,

DOI: https://doi.org/10.62017/tektonik

2020). Research was conducted on the X Jakarta Apartment construction project using the Pareto's Law 20-80 method. The results obtained in the study were that the waste of reinforcing steel material was 3.30% (Faruki & Wiyanto, 2023). Research was conducted on building construction projects in Jakarta using the linear programming method. The results obtained in the study were that the waste of reinforcing steel material was 4% for Project X and 4.51% for Project Y (Margaretta & Gondokusumo, 2018). Research conducted on development projects in the Netherlands shows that construction projects reach 9% of all materials end up being waste. The amount of waste material in a project determines the costs incurred by the contractor, starting from the construction stage and continuing through the demolition stage. As a result, contractors are required to have good management of construction waste management. (Bossink & Brouwers, 1996).

The expected objectives of this research are to calculate the amount of waste level and cost of one of the construction wastes, namely reinforcing steel, according to the Shop Drawing, and to identify the wasted costs due to the waste level of steel reinforcement material in steel reinforcement work. This study only calculates the waste level planning caused by the planning of cutting the remaining material and excess material purchases. This research is a suggestion for determining the waste level value to minimize the remaining material and reduce costs on steel reinforcement work and as a reference for similar research fields in the future.

METHOD

This research uses a quantitative approach to calculation with the help of Microsoft Excel. The case study used results from the researcher's exploration of the data obtained. This study will calculate the waste level of reinforcing steel material and waste costs caused by the remaining cutting material and excess purchases against the needs. This research uses primary and secondary data derived from data and information collected from various sources such as contractors, implementers, and so on. Shop Drawing is obtained from the data of the Construction Development Project in Surabaya, while other data is Analysis of Unit Price of Work using the nearest location.

The next stage is calculating material requirements according to the Shop drawing. In this stage, materials are grouped according to size and shape in steel reinforcement work to produce a Bar Bending Schedule (BBS). This calculation shows the value of material requirements and waste due to cutting the remaining material. The calculation is done by considering whether the waste material can be used again. In this study, the calculation took the structural work of the Construction Development Project in Surabaya, including pile caps, columns, beams, and slab.

The calculation of the waste level of material due to the remaining cutting of the material is done by maximizing the use of one reinforcing steel longer but must comply with existing regulations. This stage will produce the amount and percentage of steel reinforcement material waste. In comparison, the material waste level due to excess material is carried out from the difference in material purchases to the planning of material requirements and produces a percentage and weight. Then, the two effects are summed up to make a total percentage. The percentage is then used to calculate the waste cost. The material price used to calculate waste cost is taken from the Analysis of the Unit Price of Work using the nearest location.

RESULTS AND DISCUSSION

Material Requirement Analysis

At this stage, we will analyze the material data from the planning volume and material purchases. The planning volume is obtained from the processing of the Bar Bending Schedule (BBS) recapitulation, while the purchase volume is obtained from monitoring the contractor's purchase of reinforcing steel. The analysis results are as follows:

Table 1. Percentage of Purchase Volume to Plan Volume

No	Rebar Diameter (mm)	Plan Volume (Bar)	Weight (Kg)	Volume of Purchases (Bar)	Weight (Kg)	Percentage of Purchases (%)
1	Ø6	461	1228	490	1305	6.30%
2	Ø8	0	0	0	0	0.00%
3	Ø10	4849	35880	5070	37518	4.60%
4	Ø12	10175	108425	10624	113209	4.40%
5	D13	7175	89731	7525	94108	4.90%
6	D16	1585	30026	1597	30254	0.80%
7	D19	1818	48566	1992	53214	9.60%
8	D22	1518	54369	1680	60171	10.70%
9	D25	888	41070	899	41579	1.20%
Average (%)						**5,3%**

Based on the data above, it can be seen that the average purchase of reinforcing steel is greater than the planning material requirements, which is an average of 5.3%. Reinforcing steel with a diameter of 22 mm has the largest percentage of purchases against the need, namely 10.7%. In comparison, the smallest percentage of purchases is owned by reinforcing steel with a diameter of 16 mm, namely 0.8%.

Analysis of Waste Level

Material waste can occur for several reasons. This study only examines the planning of material waste caused by the remaining cutting material and excess material purchases. The volume of residual cutting material is calculated based on the results of secondary data processing Bar Bending Schedule (BBS), while the purchase volume is obtained from the difference in monitoring the purchase of reinforcing steel against the volume of needs. The calculation analysis can be seen in the following table:

Table 2. Volume of Waste Material from Cutting

No	Rebar Diameter (mm)	Waste of Cutting Materials (kg)
1	Ø6	43.47
2	Ø8	0.00
3	Ø10	727.78
4	Ø12	843.84
5	D13	1442.15
6	D16	3024.00
7	D19	4008.60
8	D22	4084
9	D25	9060
Total		23234

From the table above, it can be seen that the total waste material level caused by the remaining cutting material is 23234 kg. Reinforcing steel with a diameter of 25 mm has the most significant waste weight of 9060 kg, while reinforcing steel with a diameter of 6 mm has the smallest waste weight of 43.47 kg.

Table 3. Volume of Waste Material Due to Excess Purchase Material

No	Rebar Diameter (mm)	Volume of Purchases (Bar)	Used Planning Volume (Bar)	Unused Planning Volume (Bar)	Waste of Excess Materials (Kg)
1	Ø6	490	461	29	77.26
2	Ø8	0	0	0	0.00
3	Ø10	5070	4849	221	1637.87
4	Ø12	10624	10175	449	4784.54
5	D13	7525	7175	350	4377.10
6	D16	1597	1585	12	227.33
7	D19	1992	1818	174	4648.24
8	D22	1680	1518	162	5802.19
9	D25	899	888	11	508.75

After analyzing the causes of waste levels as in the table above, the next step is to calculate the waste level to determine the volume of waste or waste generated in each job to be studied. The calculation of waste level uses the approach method with the following formula (Poon et al., 2001):

$$\text{Waste Level} = \frac{\text{volume waste}}{\text{material requirement volume}}$$

Description:
Volume *waste* : material volume – Used Material Volume
Material requirement volume : the volume of material requirements under review

Table 4. Results of Waste Level Calculation against Purchase Volume

No	Rebar Diameter (mm)	Total Weight of Purchase (Kg)	Waste of Cutting Material (kg)	Unused Material Waste (Kg)	Total Waste (Kg)	Percentage of Waste (Kg)
	a	b	c	d	e = c + d	f = (e/b) *100%
1	Ø6	1305	43.47	77.26	120.72	9.2%
2	Ø8	0	0	0.00	0	0.0%
3	Ø10	37518	727.78	1637.87	2365.64	6.3%
4	Ø12	113209	843.84	4784.54	5628.38	5.0%
5	D13	94108	1442.15	4377.10	5819.25	6.2%
6	D16	30254	3024	227.33	3251.32	10.7%
7	D19	53214	4008.60	4648.24	8656.84	16.3%
8	D22	60171	4084.40	5802.19	9886.59	16.4%
9	D25	41579	9059.73	508.75	9568.48	23.0%
Total (Kg)		**431358**	**23234**	**22063**	**45297**	
Percentage of Waste Level (%) = (Total *Waste*/ Total Weight of Purchase) *100%						**10.50%**

The table above shows that the total weight of reinforcing steel material waste caused by leftover cutting material and material purchases is 45297 kg. Reinforcing steel with a diameter of 22 mm has a total weight of waste value more significant than the others at 9886.59 kg. This is inversely proportional to the 6 mm diameter reinforcing steel, which has the smallest total weight of waste, 120.72 kg.

Meanwhile, the total percentage of waste level obtained from the analysis is 10.50%, while the material used is 89.50%. Reinforcing steel with a diameter of 25 mm owns the largest

Vol. 1, No. 4 Juli 2024, Hal. 156-162
DOI: https://doi.org/10.62017/tektonik

percentage of waste level value, 23%, while reinforcing steel with a diameter of 12 mm owns the smallest percentage, 5%.

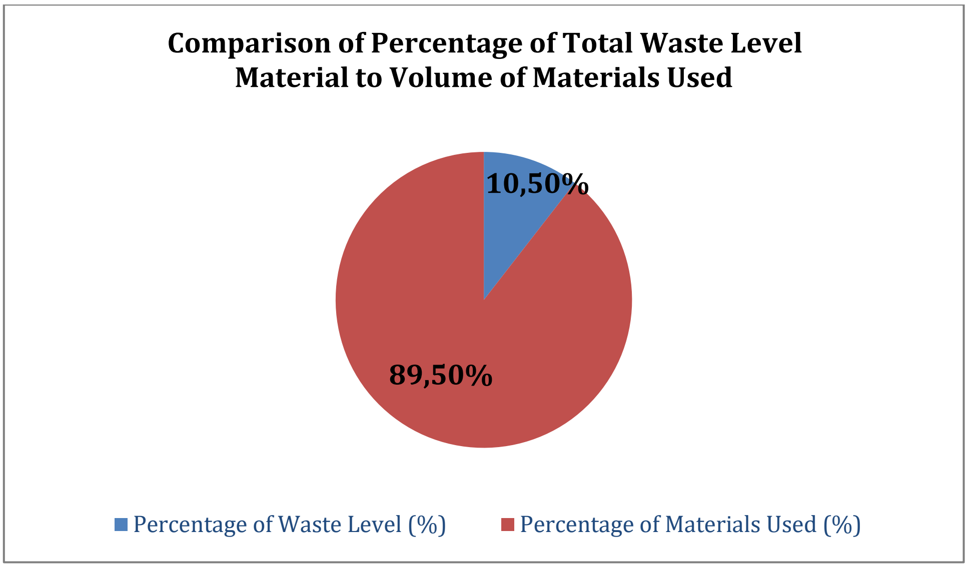

Figure 1. Comparison Chart of Percentage of Total Waste Level Material against Purchase Volume of Reinforcing Steel Material

Analysis of Waste Cost

The waste cost of reinforcing steel material will be calculated at this stage. Waste cost can be calculated to determine the loss from purchasing unused materials and can be calculated using the formula approach method (Poon et al., 2001). The waste cost calculation formula is as follows:
Waste Cost = percentage of material waste x unit price
Description:
Waste percentage : waste level x 100%
Unit price : price per unit bar or weight of the material under review

Table 5. Results of Waste Cost Calculation

No	Rebar Diameter (mm)	Waste Level (%)	Volume of Purchases (Kg)	Unit Price/kg (IDR)	Total Price (IDR)	
	a	b	c	d	e = (b*c*d)	
1	Ø6	9.2%	1305	IDR 9,500	IDR	1,146,872
2	Ø8	0.0%	0	IDR 9,500	IDR	-
3	Ø10	6.3%	37518	IDR 9,500	IDR	22,473,617
4	Ø12	5.0%	113209	IDR 9,500	IDR	53,469,604
5	D13	6.2%	94108	IDR 9,500	IDR	55,282,837
6	D16	10.7%	30254	IDR 9,500	IDR	30,887,585
7	D19	16.3%	53214	IDR 9,500	IDR	82,239,941
8	D22	16.4%	60171	IDR 9,500	IDR	93,922,595
9	D25	23.0%	41579	IDR 9,500	IDR	90,900,571
Total *Waste Cost*					**IDR**	**430,323,622**
Total Contract Value					**IDR**	**5,826,435,843**
Percentage of Waste Cost (Total *Waste Cost*/ Total Contract Value) *100%					**7.39%**	

From the table above, it can be seen that the waste cost generated in the multi-storey building project is IDR. 430,323,622 where reinforcing steel with a diameter of 22 mm has the most significant nominal waste cost among others, namely IDR. 93,922,595 while reinforcing steel with a diameter of 6 mm has the most minor nominal waste cost among others, namely IDR.1,135,872. The unit price of IDR. 9,500 is obtained from an approach based on the material price in the Analysis of Unit Prices for Work for Surabaya City in 2021. In the steel reinforcement work, it is known that the total contract value is IDR 5,826,435,843. Based on the analysis, it is known that the percentage of total waste cost is 7.39%.

CONCLUSION

Based on the analysis above, the percentage of waste level planning in multi-story building construction work results in 10.50% waste material and 89.50% used material from the total material purchase. On the other hand, it is known that the percentage of waste cost generated is 7.39% with a nominal value of IDR. 430,323,622 from the total contract value of reinforcing steelwork, which is IDR. 5,826,435,843. The percentage of waste level in this project is similar to several previous reference projects, which ranges from 4% to 13%.

SUGGESTION

In this study, we only pay attention to waste due to leftover cutting and excess purchases. Further research is also expected to analyze material waste for reasons other than these. Additional research is needed regarding material quantity calculation based on daily reports.

REFERENCES

Atmaja, J., Adibroto, F., & Hidayah, N. (2020). Optimasi Pemotongan Besi Tulangan Pada Pekerjaan Struktur Menggunakan Metode Linear Programming. *Borneo Engineering : Jurnal Teknik Sipil*, *4*(2), 192–202. https://doi.org/10.35334/be.v4i2.1595

Bossink, B. A. G., & Brouwers, H. J. H. (1996). Construction Waste: Quantification and Source Evaluation. *Journal of Construction Engineering and Management*, *122*(1), 55–60. https://doi.org/10.1061/(ASCE)0733-9364(1996)122:1(55)

Faruki, R. R., & Wiyanto, H. (2023). Analisis Waste Material dan Faktor Penyebab Pada Proyek Apartemen X. *JMTS: Jurnal Mitra Teknik Sipil*, 863–872. https://doi.org/10.24912/jmts.v6i4.24888

Gavilan, R. M., & Bernold, L. E. (1994). Source Evaluation of Solid Waste in Building Construction. *Journal of Construction Engineering and Management*, *120*(3), 536–552. https://doi.org/10.1061/(ASCE)0733-9364(1994)120:3(536)

Kareem, K. R., & Pandey, R. K. (2013). Study of Management and Control of Waste Construction Materials in Civil Construction Project. *International Journal of Engineering and Advanced Technology*, *2*(3). https://doi.org/10.13140/RG.2.2.31476.65923

Margaretta, J., & Gondokusumo, O. (2018). Penerapan Metode Linear Programming Untuk Analisis Pemotongan Besi Tulangan Pada Proyek Bangunan Gedung Di Jakarta. *Jurnal Muara Sains, Teknologi, Kedokteran Dan Ilmu Kesehatan*, *1*(2). https://doi.org/10.24912/jmstkik.v1i2.1029

Muka, I. W., Widyatmika, M. A., & Antara, I. M. N. (2020). Analisis Perbandingan Waste Besi Tulangan Metode Konvensional Dengan Software Cutting Optimazation Pro. *Teknika*, *15*(2), 41. https://doi.org/10.26623/teknika.v15i2.2852

Poon, C. ., Yu, A. T. ., & Ng, L. . (2001). On-site sorting of construction and demolition waste in Hong Kong. *Resources, Conservation and Recycling*, *32*(2), 157–172. https://doi.org/10.1016/S0921-3449(01)00052-0

Putra, G. M. (2020). *Analisis Sisa Material Konstruksi Pada Proyek Gedung Laboratorium Terpadu Fakultas Teknik Universitas Jember Menggunakan Diagram Pareto* [Universitas Jember]. https://repository.unej.ac.id/handle/123456789/101797

DOI: https://doi.org/10.62017/tektonik

Widhiawati, I. A. R., Astana, Y., & Indrayani, N. L. A. (2019). Kajian Pengelolaan Limbah Konstruksi Pada Proyek Pembangunan Gedung di Bali. *Jurnal Ilmiah Teknik Sipil*, *23*(1), 55–61. https://doi.org/https://doi.org/10.24843/JITS.2019.v23.i01.p07

Widiasanti, I., & Lenggogeni. (2013). *Manajemen Konstruksi* (Pipih Latifah (ed.); Cetakan pe). Penerbit PT. Remaja Rosdakarya.

Yuni, N. K. S. E., Yuliana, N. P. I., & Sudiarta, I. K. (2023). Analisa waste material besi dalam upaya pengendalian sisa material konstruksi. *Jurnal Teknik Sipil Terapan*, *5*(1), 22. https://doi.org/10.47600/jtst.v5i1.561