ASTONJADRO

pISSN 2302-4240
eISSN 2655-2086

Volume 14, Issue 1, February 2025, pp.0281-0289
DOI: http://dx.doi.org/10.32832/astonjadro.v14i1 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Optimizing Reinforcement Requirements for Inspection Road Works Using Cutting Optimization Pro Software on the SANUR Port Project

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| Submitted: July 03, 2024 | Revised: December 22, 2024 | Accepted: December 28, 2024 |

| Published: January 03, 2025 |

ABSTRACT

Construction project is a long process, where in its implementation there are many problems that must be resolved. One of the problems that is often encountered is uncontrolled use of materials, resulting in construction waste. This condition occurs because the control system implemented still uses a conventional system, namely relying only on the performance of craftsmen in the field without any control over the possible patterns of cutting the remaining reinforcing waste with the type of rebar that will be used next manually. So the method for reinforcing steel work that is suitable to be carried out in the field is to prepare a Bar bending schedule (BBS). BBS is a calculation method to determine the length of each iron required, the amount of reinforcing iron to be used and the total weight of all the iron to be installed in a structure. As in the Sanur Port Project, specifically on the South Breakwater Inspection Road sub-work, where based on the calculation results, it was found that the waste level value produced based on the Bar bending schedule (BBS) method using the Cutting Optimize Pro application was smaller when compared to the manual waste level value. . Where optimization using the cutting optimization pro software compared to the manual method can optimize the use of rebar rods by 9.88% with a waste level value of 0.58%.

Keywords: construction projects; waste material; optimization; manual methods; bar bending schedule; cutting optimization pro software.

INTRODUCTION

In an effort to support equitable National Development, the Indonesian Government has intensified various developments in all sectors, one of which is in the form of construction projects. Construction project activities are a long process, where in its implementation many problems are encountered that must be resolved (Mahapatni et al., 2022). One of the problems that is often encountered is uncontrolled use of materials. The implementation of a building construction project will not avoid the appearance of leftover construction materials or what is usually called construction waste. Waste construction materials are not only important from an efficiency standpoint, but also have an impact on the environment. (Perdana et al., 2018),

Leftover material (waste) if not controlled can cause cost overruns. If we look at the influence of factors causing material waste on construction activities, then non-optimal material cutting methods are the factors that most influence the occurrence of material waste (Mahapatni et al., 2022). Just like what happened in the ironworks. In the field, sometimes quite a lot of scrap metal remains that cannot be used, thereby reducing the cost efficiency of the work. This condition occurs because the control system implemented still uses a conventional system, namely relying only on the performance of craftsmen in the field without any control by manually matching the possible cutting patterns of the remaining waste reinforcing steel with the type of reinforcing steel that will be used next (Muka et al. , 2020).

The manual cutting pattern for iron does not take into account the efficiency of the cutting pattern properly and the utilization of remaining iron pieces is only adjusted according to the field conditions available manually, causing the remaining pieces of iron to not be installed effectively. Contractors must innovate to reduce remaining reinforcement when manufacturing reinforcing steel. A common way to reduce material waste is material management, but this method is not effective because it only improves management, not work methods in the field. (Muka et al., 2020).

A suitable method for reinforcing steel work in the field is to prepare a Bar bending schedule (BBS). BBS is a calculation method to determine the length of each iron required, the amount of reinforcing iron to be used and the total weight of all the iron to be installed in a structure. Calculations for the BBS method depend on shop drawings approved by the consultant and the calculations refer to the aspects contained in SNI (Kifyati et al., 2017). Based on the 2018 General Specifications for the Directorate General of Highways, revision 2, regarding procedures for detailing concrete reinforcement for road and bridge construction work, it refers to SNI 03-6816-2002 and also considers SNI 2847:1992, the latest version of which has now been published, namely SNI 2847 :2019.

Regarding the steel work on the Sanur Marine Facilities Development Project, specifically on the South Breakwater Inspection Road sub-work, where the volume of iron work on this project is quite large, reaching 140 tons, this causes the potential for iron waste to become even greater. To optimize the steel cutting pattern, an analysis of the optimization of reinforcing steel cutting using Cutting Optimization Pro software can be recommended for the Inspection Road work at the Sanur Marine Facilities Development Project.

Construction Projects

A construction project is a project related to efforts to build an infrastructure building, which generally includes basic work that falls into the fields of civil engineering and architecture. Construction projects are projects related to development efforts. Development in a construction project is a long process, in its implementation there are many problems that must be resolved. Problems and obstacles that often occur in construction projects are inefficiency and waste in the implementation of construction (Apni et al., 2019).

Construction Materials

Materials are items (goods) purchased or made, which are stored for later use, either for use, further processing or sale. Meanwhile, according to the main dictionary, the scientific term material is objects or building materials needed to make another item; material. Material management is a system that coordinates activities to plan and monitor the volume and time of material procurement through receipt/acquisition, change of form, and movement of raw materials, materials in process and finished materials (Labombang et al., 2012).

Waste of Construction Materials

Material waste in a construction project is the remaining material that is not used, as a result of the construction, repair or change process. Waste in the form of material is also defined as goods that arise as a result of production from processes or accidents that cannot be immediately reused without further treatment. Another definition of waste in the form of material is material resources that are in excess or have been used, including those that can be reused, can be recycled, can be returned to suppliers, or transferred to places where they can be reused by others (Handayani et al., 2020).

Causes of Residual Reinforcing Iron Material

According to Kim (2004), the amount of material lost/waste can reach 3-10% of the amount of material at the bidding stage. Kim (2004) shows that the rate of loss of reinforcing steel from a construction project is greater than in buildings that tend to use the same length and size of reinforcement repeatedly.

The main causes that influence the amount of waste material are as follows: 1. Ordering reinforcement at steel factories that is not accurate and in accordance with the construction and "bar schedule" and does not pay attention to surplus reinforcement from the construction process.

Material

Material is also wasted when reinforcement with a length of 2-3 meters is no longer used after being cut. The most effective is if the cutting length is at least 1 meter, because the cost of cutting reinforcement with a size below 1 meter will be more expensive. Savings of up to 1% can be achieved if reinforcement design is carried out taking into account structural drawings and the selection and combination of appropriate reinforcement sizes can be carried out so that no residue of more than 1 m is produced (Kim, 2004).

Research also shows that there is a possibility of a 1% loss rate if reinforcement is cut without considering the bending margin.

One of the most frequent occurrences is failure of inventory management from cutting and bending reinforcement.

Uncontrolled quality of reinforcement work.

Management errors in reinforcing steel fabrication and layout of cutting machines and rebar bending machines.

The quality of workers employed by sub contractors

Waste Level

This waste level is calculated to determine the volume of waste from each material item being studied. This waste level is calculated using an approximation method with the general formula:

Waste level =(Vol.Waste)/(Vol. Available Material) (2.1) Waste volume = available material volume – installed material volume.

Volume of available material = total arrival volume of the material under review (Mahapatni et al., 2022).

Cutting optimization pro software

Cutting optimization pro software was developed by Optimal Programs SRL, this software provides the most optimal results for cutting reinforcing steel, apart from cutting methods, this software also provides data on iron material available in the field so that controlling iron material becomes easier and more efficient.

The terms of application of the software are as follows:

1. Prepare bestat data (BBS), which relates to details of the reinforcement such as cutting patterns, length, and the amount of reinforcing steel needed.
2. For implementation in the field in applying the software output, you must ensure that the area of the structure to be calculated has taken into account the availability of land for iron stock. Besides that,

The cutting operator must understand the data output from the software and carry out iron cutting according to the output from the software. Data input is carried out according to the type of reinforcing steel to facilitate input and control in the field.

RESEARCH METHODS

This research uses a quantitative descriptive method because the analysis discussed in this report is in the form of iron waste calculations. The research was carried out by analyzing the value of iron waste resulting from calculations based on the Bar bending schedule (BBS) method using the Cutting optimization pro application which was then compared with the results of manual iron waste calculations, as well as identifying the effectiveness of using the Cutting Optimization Pro application based on the results of these two calculations. .

Research Location and Time

The location taken to carry out this research was the Sanur Sea Port Development Project, precisely at the South Breakwater Inspection Road sub-work which is located at Jalan Pantai Matahari Terbit, Sanur Kaja, South Denpasar, Bali. This research was conducted from September 2022 to December 2023.

Research Steps

Formulating the Problem

The first step that must be taken is to find and formulate the problem of the topic being discussed.

Study of literature

Next, carry out literature studies by reading books, journals and other related media that have credible and reliable sources.

Determine Data Type and Source

The data source in research is the subject from which the data is obtained. To obtain good research results, of course, they must be supported by accurate data in accordance with what is desired. This data must always be extracted from sources related to the problem being studied. The data sources used in this research are as follows:

Primary data

Primary data is data obtained or collected directly in the field by people conducting research in the form of interviews, opinion polls from individuals or groups (people) or the results of observations of an object. The primary data that the author uses in this research are as follows:

Types and Bending Patterns of Reinforcement

Secondary Data

Secondary data is data obtained or collected by people conducting research from existing sources. This secondary data was taken directly from the Sanur Sea Port Development Project. Secondary data required is:

1. Draw a plan

2. Planned volume of reinforcement work

3. Actual volume of iron

Data analysis

1. Analysis of manual iron work waste by calculating based on steel volume data from as-built drawings compared to the actual volume of iron used in the field.
2. Analysis of iron work waste based on the Bar bending schedule (BBS) method by redesigning the iron cutting pattern based on plan drawings and SNI and carrying out calculations using the Cutting optimization pro application.
3. Comparative analysis of iron waste results based on the Cutting optimization pro application with manual iron waste values.

RESULTS AND DISCUSSION

Calculation of Reinforcement Volume for Southern Breakwater Inspection Road Works

The volume of reinforcing iron is obtained from calculations based on as-built drawings of inspection road work at South Breakwater. The following is the calculation of the total volume of reinforcing iron for 80 sections according to table 1 as follows:

Table 1. Recapitulation of calculations for the volume of reinforcing steel

Diameter (mm)	Reinforcement Iron Volume		
	Iron Weight (kg/m)	Total Length (m)	Total Weight (kg)
1	2	3	4 = 2 x 3
D-16	1.578	79.200	124.996,61
D-32	6.313	480	3.030,22
Total			**128.026,83**

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Volume of Reinforcement Material Arrivals

The volume of imports of reinforcing steel material was obtained directly from the contractor, while the data on total iron arrivals in table 2 is as follows:

Table 2. Recapitulation of reinforcement arrivals

No	Date	Volume				Description
		D 16		D32		
		Bar	Kg	Bar	Kg	
1	January 12, 2022	1251	23.688,9			BJTS 420 B
2	February 18, 2022	1800	34.084,8	50	3.787,78	BJTS 420 B
3	March 25, 2022	700	13.255,2			BJTS 420 B
4	March 09, 2022	1800	34.084,8			BJTS 420 B
5	August 19, 2022	1800	34.084,8			BJTS 420 B
Total		**7351**	**139.198,5**	**50**	**3.787,78**	

Calculation of waste level of reinforcing steel based on manual methods

Waste Volume = available material volume – installed material volume
= (139.198,50 + 3.787,78) kg – 128.026,83 kg
= 142.986,28 kg – 128.026,83 kg
= 14.959,45 kg

Waste level = (Vol.Waste)/(Vol. Material Tersedia)
= 14.959,45/142.986,28
= 10,46 %

Waste Level of Iron Reinforcement using the Bar bending schedule (BBS) method based on Cutting Optimization Pro software

Repetition Pattern 1

The recap of the iron volume calculation according to the details of type 1 reinforcement according to table 3 is as follows:

Table 3. Recap of reinforcement volume for reinforcement pattern 1

Reinforcement Type	Reinforcement Length (m)	Number per sectio (unit)	Length per section (m)	Number of Sections	Total Length (m)
1	2	3	4 = 2 x 3	5	6 = 4 x 5
Tul. A1	2,60	30	78	80	6.240
Tul. A2	2,00	30	60	80	4.800
Tul. B1	1,60	30	48	80	3.840
Tul. B2	1,00	30	30	80	2.400
Tul. C1	5,60	30	168	80	13.440
Tul. C2	5,00	30	150	80	12.000
Tul. D	6,00	79	474	80	37.920
Tul. E	0,50	12	6	80	480
Diameter			**D16**	**D32**	
Total Length (m)			80.640,00	480,00	
Iron Weight/m (kg)			1.57	6,31	
Total Weight (kg)			127.269,27	3.030,22	

The following is the calculation of waste level for reinforcement pattern 1 according to table 4 below:

Table 4. Calculation of the volume of reinforcing steel for cutting pattern 1 with SCOP

Diameter (mm)	Reinforcement Iron Volume			Cutting optimization pro	
	Iron Weight (kg/m)	**Total Length (m)**	**Total Weight (kg)**	**Iron Requirement (bar)**	**Total Weight (kg)**
1	2	3	4 = 2 x 3	5	6 = 2 x 5
D-16	1.578	80.640	127.269,27	6.760	128.026,83
D-32	6.313	480	3.030,22	40	3.030,22
Total		**X**	**130.299,49**	**Y**	**131.057,05**

Waste level = $Vol.Waste$

Available Steel = 131.057,05−130.299,49

131.057,05

= 757,56

131.057,05

= 0,58 %

The waste level of iron produced based on analysis using cutting optimization pro software for cutting pattern 1 which consists of 8 types of reinforcement patterns is 0.58%.

Repetition Pattern 2

The recap of the iron volume calculation according to the details of type 2 reinforcement according to table 5 is as follows:

Table 5. Recap of reinforcement volume for reinforcement pattern 2

Reinforcement Type	Reinforcement Length (m)	Number per sectio (unit)	Length per section (m	Number of Sections	Total Length (m)
1	2	3	4 = 2 x 3	5	6 = 4 x 5
Tul. A1	2,30	60	138	80	11.040
Tul. B1	1,30	60	78	80	6.240
Tul. C1	5,30	60	318	80	25.440
Tul. D	6,00	79	474	80	37.920
Tul. E	0,50	12	6	80	480
Diameter				**D16**	**D32**
Total Length (m)				80.640,00	480,00
Iron Weight/m (kg)				1,57	6,31
Total Weight (kg)				127.269,27	3.030,22

The following is the calculation of waste level of reinforcement according to table 6 below:

Table 6. Calculation of Reinforcement Volume for Cutting Pattern 2 with SCOP

Diameter (mm)	Reinforcement Iron Volume			Cutting optimization pro	
	Iron Weight (kg/m)	**Total Length (m)**	**Total Weight (kg)**	**Iron Requirement (bar)**	**Total Weight (kg)**
D-16	1.578	80.640	127.269,27	6760	128.088,48
D-32	6.313	480	3.030,22	40	3.030,22
Total	**X**		**130.299,49**	**Y**	**131.057,05**

Waste level = $Vol.\ Waste$

Available Steel = 131.057,05 −130.299,49

131.057,05

= 757,56

131.057,05

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= 0,58 %

The waste level of iron produced is based on analysis using cutting optimization pro software for cutting pattern 2 which consists of 5 types of reinforcement patterns is 0.58%.

Repetition Pattern 3

The recap of the iron volume calculation according to the details of type 3 reinforcement according to table 7 is as follows

following:

Table 7. Recap of type 3 reinforcement reinforcement volume

Reinforcement Type	Reinforcement Length (m)	Number per sectio (unit)	Length per section (m	Number of Sections	Total Length (m)
1	2	3	4 = 2 x 3	5	6 = 4 x 5
Tul. A	2,40	60	144	80	11.520
Tul. B	1,40	60	84	80	6.720
Tul. C	5,40	60	324	80	25.920
Tul. D	6,00	79	474	80	37.920
Tul. E	0,50	12	6	80	480
Diameter			**D16**		**D32**
Total Length (m)			82.080,00		480,00
Iron Weight/m (kg)			1,57		6,31
Total Weight (kg)			129.541,94		3.030,22

The following is the calculation of waste level of reinforcement according to table 8 below:

Table 8. Calculation of the volume of reinforcing steel for cutting pattern 3 with SCOP

Diameter (mm)	Reinforcement Iron Volume			Cutting optimization pro	
	Iron Weight (kg/m)	**Total Length (m)**	**Total Weight (kg)**	**Iron Requirement (bar)**	**Total Weight (kg)**
D-16	1.578	80.640	129.541,94	7000	132.636,00
D-32	6.313	480	3.030,22	40	3.030.22
Total	**X**		**132.572,16**	**Y**	**135.667,68**

Waste level = $Vol. Waste$

Available Steel = 135.667,68 −132.572,16

135.667,68

= 3.095,52

135.667,68

= 2,28 %

The waste level of iron produced based on analysis using cutting optimization pro software for cutting pattern 3 which consists of 5 types of reinforcement patterns is 2.28%. Based on the calculation results, it was found that the cutting pattern that produces the most optimal waste level of iron is cutting pattern 2, because the waste level produced is the lowest and the workmanship aspect is easier because there are fewer types of reinforcement patterns than reinforcement pattern 1.

Comparison of Waste Iron Level Analysis

From the analysis results, it can be seen the waste produced through manual methods and using the SCOP application. A summary of waste results can be seen from table 9 below:

Table 9. Comparison of calculations using manual and application methods

Reinforcement Type	Quantity (kg)	Waste iron (kg)	WasteLevel
Manual	142.986,28	14.959,45	10,46%
COP Pola 2	131.057,05	757,56	0,58%
Deviation			9,88%

Based on the results of calculating the waste level of iron, it was found that the waste level of reinforcing steel based on the Cutting Optimization Pro software was more optimal when compared to manually.

CONCLUSION

In preparing this research using Cutting Optimization Pro Software on the Inspection Road Work in the Sanur Sea Facilities Development Project, the following conclusions can be drawn, 1) the waste level produced in the steel work using manual methods on the Inspection Road Work at the Sanur Sea Port Project is 14,959, 45 kg, 2) the waste level produced in the steel work based on the Bar bending schedule (BBS) method using the cutting optimization pro application on the Sanur Sea Port Project Inspection Road Work was 757.56 kg, 3) based on the calculation results, it was found that the waste value The level produced based on the Bar Bending Schedule (BBS) method using the Cutting Optimization Pro application is smaller when compared to the manual waste level value. Where steel optimization using the cutting optimization pro application compared to manual methods can minimize the use of iron rods by 9.88% with a resulting waste level value of 0.58%.

REFERENCES

Apni., N. 2019. Faktor-Faktor Penyebab Construction Waste Pada Proyek Konstruksi Di Kota Palangka Raya.

Arifin., D., Saputra, A. J., Savitri, A. 2022. Efektisitas Pembesian Pada Proyek Panbill Mallchedule SNI2847-2019, BS-8666-2005, dan Linear Programming.

Departemen PU. 2002. Pendetailan Tulangan Beton SNI 03-6816-2002.

Departemen PU. 2014. Baja Tulangan Beton SNI 2052:2014.

Juzailah, T. H. 2020. Analisis Potensi Pemborosan Material dan Solusi Penanganannya pada Proyek Pembangunan Gedung Bertingkat.

Kementrian PUPR. 2020. Spesifikasi Umum Tahun 2018 Untuk Pekerjaan Kontruksi Jalan Dan Jembatan (Revisi 2).

Kifyati, F. 2017. Analysis Of Bar Needed And Waste By Using Barbequeprosoftware On The Box Traffic Sta.421+803,2 Batangsemarang Section 3 Main Road Construction Project.

Kim, S. K., Won, K. H., Jin, K. J. 2004. Algorithms for Reducing the Waste Rate of Reinforcement Bars. Journal of Asian Architecture and Building Engineering. hal 18.

Labombang, M. 2012. Manajemen Penggunaan Material Pada Pekerjaan Tanggul Sungai Pondo-Poboya.

Liem, A. G., Sulistio, H. 2020. Studi Analisis Persentase Waste Besi Beton Dan Faktor Penyebabnya Pada Bangunan Bertingkat Rendah Di Jakarta.

Mahapatni, I A. P. S., Juliana, I K. I. 2022. Analisis Waste Level Dan Waste Cost Bekisting DanPembesian Pada Pekerjaan Struktur ProyekKonstruksi.

Muka,I W.,Widyatmika, M. A., Antara, M. N. 2020. Analisis Perbandingan Waste Besi Tulangan Metode Konvensional Dengan Software Cutting Optimazation Pro.

Perdana, A. S., Indrayadi, M., Pratiwi, R. 2018. Identifikasi Construction Material Waste Pada Proyek Pembangunan Gedung.

Suryanto, H. S. 2020. Analisis Sisa Material Besi Tulangan Pada Proyek Konstruksi Bangunan Gedung.

Wiguna,I P. A. 2007. Peningkatan Kompetensi Sumber Daya di Industri Konstruksi dalam Melakukan Optimalisasi Sistem Pembesian Struktur dengan Berbasiskan. Web Based Training. Jurnal : Teknik Sipil FTSP. Institut Teknologi 10 Nopember (ITS) Surabaya.