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Construction Material Waste at the "Apartment X" Project in Bekasi, West Java, Indonesia

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ABSTRACT: The implementation of a construction project activity is a lengthy process that is fraught with numerous issues and challenges. The presence of a lot of material waste is one of them. Waste material in the form of concrete rebar was also discovered at the "Apartment X" project in Bekasi, West Java. This research was carried out through interviews, questionnaire distribution, and observation. The findings of the research revealed that the largest percentage of concrete rebar waste in several columns work is D19 rebar waste with a percentage of 18.35%; then the largest percentage in partial wall of STP work is D16 rebar waste with a percentage of 1.29%. Carelessness and worker mistakes, followed by lack of workforce skills, are the factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java, the contractor should have a good quality control system and supervise the workers involved in concrete rebar properly in order to minimize errors that may result in the occurrence of excessive waste. The contractor should also ensure that all parties involved with concrete rebar, from the engineering side to the field implementer, have the capacity to carry out the work that will be assigned.

KEYWORDS: Rebar Waste, Factors, Causes of Waste

INTRODUCTION

A nation's infrastructure plays a significant role in promoting economic progress. Good infrastructure will entice investors to come and invest their money if it is available. As a result, the economic growth will be evenly distributed and have a favorable effect on the areas where the investment is made. Nowadays, numerous structures and other infrastructure are being constructed in nearly every location to support the activities of the general population. This could indicate that the development of construction projects in Indonesia is accelerating.

However, despite the industry's rapid progress, there are still several challenges and issues that arise when carrying out construction project work. The implementation of a construction project activity is a lengthy process that is fraught with numerous issues and challenges (Ervianto, 2005). The fact that there is a lot of material waste produced by activities related to building work is one of the issues that is frequently experienced.

In reality, construction waste occurs throughout the construction industry (Alwi et al., 2002). Waste material can occur in building projects as a result of numerous issues. To reduce the probability of material waste, careful consideration must be given to the selection of materials, handling during transportation, storage, and handling of materials during work implementation.

In implementing construction projects, residual material or construction waste cannot be avoided (Hadut & Koesmargono, 2018). It also occurred in the construction of "Apartment X" in Bekasi, West Java. Initial observations revealed the presence of construction waste in the form of concrete rebar at the "Apartment X" project in Bekasi, West Java. It is feared that failure to take steps to reduce material waste will be harmful to the project parties and the preservation of the area around the project.

CONSTRUCTION WASTE

Waste can be defined as all kinds of loss of material, time and monetary results from an activity but does not add value or process to the product (Al-Moghany, 2006). In simple terms, to identify waste, it is "something that can be eliminated without reducing customer value", it can be an activity, resource, rule, etc. (Polat & Ballard, 2004).

Waste is considered as one of the primary issues in the construction industry. All activities that incur costs, either directly or indirectly, take time and resources but do not add value to a product, can be called non-value adding activities (Koskela, 1992). Construction waste does not only focus on the quantity of waste material in the field, but is also related to several things such as waiting time, material handling and worker movement (Formoso et al., 1999).

Construction waste, is waste in the form of leftover construction materials and other waste from activities during

construction, demolition and land clearing at the start of project implementation (Putra et al., 2018). Construction waste refers to solid waste that does not contain liquids and hazardous substances, mostly inert waste resulting from structural construction work, including all types of buildings as well as roads and bridges (Chen et al., 2002).

According to Skoyles (1976), based on the causes, construction waste can be classified into 2 categories. First, indirect waste, is leftover substance that manifests as dissipation (monetary loss) due to excess use of material volumes than planned and cannot be seen as waste on the field. Second, direct waste, is leftover material that arises in a project because it is damaged and cannot be repaired and reused during the construction process.

There are 2 primary categories of material waste in construction projects (Skoyles & Skoyles, 1987):

1. Waste from structural work

For example: cement, coral, sand, concrete rubble, reinforcement rebar, wooden formwork, etc.

2. Waste from finishing work

For example: broken or damaged materials in ceramics and leftover paint due to careless work.

RESEARCH METHOD

Research Plan

This research attempts to find out the percentage of concrete rebar waste at the "Apartment X" project in Bekasi, West Java, during the research period; find the factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java; and knowing how to minimize the factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java.

This research was carried out referring to the following research plan table:

Table 1. Research Plan

No	Attempts of Research	Research Methodology	Data Obtained	Data Analysis
1	Find out the percentage of concrete rebar waste at the "Apartment X" project in Bekasi, West Java during the research period	Limited interviews and field observations	The percentage of concrete rebar waste during the research period	Quantitative analysis based on field measurements
2	Find the factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java	Questionnaire survey	The factors that influence the occurrence of concrete rebar waste at the "Apartment X"	Statistical analysis with the SPSS software
3	Knowing how to minimize the factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java	Interview	Suggestions to minimize the factors that influence the occurrence of concrete rebar waste at the "Apartment X"	Qualitative analysis of expert advice

Research Variables

After reviewing the literature, we identified several factor variables that influence the occurrence of material waste which commonly occurs in construction projects. The following variables will subsequently be added to the questionnaire used for this research:

Table 2. Variables that Influence the Occurrence of Material Waste

Cause of material waste	Research Variables	Source
X1. Factor of Manpower	X1.1 Lack of workforce skills	Journal of "Construction Waste *Pada Proyek-Proyek Konstruksi Di Daerah Istimewa Yogyakarta*" (Kaming et al., 2014)
	X1.2 Workers with no or less work experience X1.3 Doesn't adhere to the working procedures X1.4 There are physical constraints (injured) X1.5 Rude actions of workers so that the material is damaged X1.6 Carelessness and worker mistakes X1.7 Supplier delayed shipment	Journal of "Waste *Konstruksi: Identifikasi Potensi dan Penyebabnya Pada Proyek Perumahan Di Pekanbaru*" (Sapitri & Firdaus, 2019)
	X1.8 Lack of foreman X1.9 Inexperienced supervisor	Journal of "Construction Waste *Pada Proyek-Proyek Konstruksi Di Daerah Istimewa Yogyakarta*" (Kaming et al., 2014)

X2. Factor of Machine	X2.1 Equipment damaged X2.2 The repair of the equipment took quite a long time X2.3 The equipment used are unsuitable X2.4 Equipment is too conventional X2.5 Lack of equipment	Journal of "Waste *Konstruksi: Identifikasi Potensi dan Penyebabnya Pada Proyek Perumahan Di Pekanbaru*" (Sapitri & Firdaus, 2019)
X3. Factor of Method	X3.1 There are no operational standards for the work X3.2 Inconsistent working methods X3.3 The chosen construction method is incorrect X3.4 Design changes X3.5 Poor planning and scheduling	Journal of "Waste *Konstruksi: Identifikasi Potensi dan Penyebabnya Pada Proyek Perumahan Di Pekanbaru*" (Sapitri & Firdaus, 2019)
X4. Factor of Material	X4.1 Poor material quality X4.2 Material arrived late at the location X4.3 Poor material handling on site X4.4 Poor scheduling of material shipment to the location X4.5 Unsuitable material X4.6 Poor storage of material	Journal of "Construction Waste *Pada Proyek-Proyek Konstruksi Di Daerah Istimewa Yogyakarta*" (Kaming et al., 2014)
X5. Factor of Environment	X5.1 Weather	Journal of "Construction Waste *Pada Proyek-Proyek Konstruksi Di Daerah Istimewa Yogyakarta*" (Kaming et al., 2014)
	X5.2 Damage or loss by another party X5.3 Poor condition of the location	Journal of "*Faktor-Faktor Penyebab* Construction Waste *Pada Proyek Konstruksi Di Kota Palangka Raya*" (Apni & Puspasari, 2019)
	X5.4 Complaints from the people	Journal of "Waste *Konstruksi: Identifikasi Potensi dan Penyebabnya Pada Proyek Perumahan Di Pekanbaru*" (Sapitri & Firdaus, 2019)

FINDINGS AND DISCUSSION

Waste Identification

In identifying the amount of concrete rebar waste, the research was carried out with limited interviews with the project's contractors of the "Apartment X" in Bekasi, West Java and by conducting direct observations at the project site. The waste quantity is determined by direct weighing in the site for 1 week.

This was carried out to find out the percentage of concrete rebar waste at the "Apartment X" project in Bekasi, West Java during the research period. Work on several columns and partial wall of STP (sewage treatment plant) was underway when data was collected.

In any construction project, concrete rebar waste is difficult to avoid. To find out if the waste is something excessive or not, the waste data from the BBS (bar bending schedule) calculations and the waste data from the site are compared.

The data on the amount of concrete rebar used and the comparison of waste data from the BBS calculations with the waste data from the site are shown below. The percentages in Table 5 and Table 6 were obtained by the comparison with the data on the amount of concrete rebar used.

1. Data amount of concrete rebar used

a. Several columns work

Table 3. Data Quantity of Rebar Used in the Several Columns

Diameter of rebar	Quantity (kg)
D10	1273,49
D13	400,13
D19	2056,82
D22	931,01
D25	2774,16

b. Partial wall of STP work

Table 4. Data Quantity of Rebar Used in the Partial Wall of STP

Diameter of rebar	Quantity (kg)
D13	1775,57
D16	1969,34

2. Comparison of waste data from BBS calculations with the waste data from the field

a. Several columns work

Table 5. Comparison of Waste from the Several Columns

Diameter of rebar	Waste quantity from the BBS (kg)	Percentage of BBS waste	Waste quantity from the site (kg)	Percentage of site waste
D10	6,50	0,51 %	6,65	0,52 %
D13	7,98	1,99 %	10,05	2,51 %
D19	335,95	16,33 %	377,45	18,35 %
D22	114,82	12,33 %	118,15	12,69 %
D25	231,18	8,33 %	241,00	8,69 %

b. Partial wall of STP work

Table 6. Comparison of Waste from the Partial Wall of STP

Diameter of rebar	Waste quantity from the BBS (kg)	Percentage of BBS waste	Waste quantity from the site (kg)	Percentage of site waste
D13	9,99	0,56 %	10,05	0,57 %
D16	24,62	1,25 %	25,50	1,29 %

First Phase Questionnaire

Questionnaires that are created based on certain theories are reviewed with at least 3 experts to obtain expert judgment responses on the questionnaire that has been created (Dr. Suparyanto, 2010). The variables in Table 2 were then submitted to practitioners and academics as experts for responses and validation of the factors that cause the occurrence of material waste above, in order to determine whether they can influence the occurrence of concrete rebar waste in the Apartment X project in Bekasi, West Java.

The first phase of questionnaire experts consisted of 5 people, coming from the contractor on the Apartment X project in Bekasi, West Java and also from academics. The listed variables have been determined to be valid based on the findings of the first phase questionnaire. Variable codes from Table 2 are converted to a new list, as shown below:

Table 7. List of Valid Variables Based on the First Phase Questionnaire's Findings

Code	Variabels
X01	Lack of workforce skills
X02	Workers with no or less work experience
X03	Doesn't adhere to the working procedures
X04	Carelessness and worker mistakes
X05	Inexperienced supervisor
X06	Equipment damaged
X07	The equipment used are unsuitable
X08	The chosen construction method is incorrect
X09	Design changes
X10	Poor material handling on site
X11	Poor storage of material
X12	Weather

From the total number of research variables of 29 (in Table 2), the variables declared valid results of validation by experts are 12 variables. The variables stated as valid are subsequently included in the second phase questionnaire, which will then be distributed to respondents of the research.

SECOND PHASE QUESTIONNAIRE

The variables determined by the first phase questionnaire were subsequently provided to the research's respondents. The second phase questionnaire attempts to find the factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java.

There were 30 respondents, all respondents came from the contractor of the "Apartment X" project in Bekasi, West Java. To determine the factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java, the second phase questionnaire needs to perform some tests. The SPSS software is used for the test.

The Factors that Influence the Occurrence of Concrete Rebar Waste at the "Apartment X" Project

The factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java, were derived from variables that are declared as "influential" by the results of the multiple linear regression test (t scores > t table) and that are "correlated" as findings of the correlation test (Sig. scores < 0,05). The "t table" in this research has a value of 2,086. The variables are then sequenced according to their Pearson Correlation scores.

Table 8. Results of Regression Tests and Correlation Tests

No	Code	Variabels	t scores	Description	Sig.	Description	Pearson Correlation
1	X01	Lack of workforce skills	2,317	Influential	0,000	Correlated	0,686
2	X02	Workers with no or less work experience	0,556	Uninfluential	0,064	Uncorrelated	0,343
3	X03	Doesn't adhere to the working procedures	1,385	Uninfluential	0,000	Correlated	0,637
4	X04	Carelessness and worker mistakes	3,008	Influential	0,000	Correlated	0,766
5	X06	Equipment damaged	- 0,716	Uninfluential	0,330	Uncorrelated	0,184
6	X07	The equipment used are unsuitable	0,414	Uninfluential	0,192	Uncorrelated	0,245
7	X08	The chosen construction method is incorrect	0,436	Uninfluential	0,002	Uncorrelated	0,537
8	X09	Design changes	0,745	Uninfluential	0,023	Correlated	0,413
9	X12	Weather	0,900	Uninfluential	0,276	Uncorrelated	0,206

Table 9. Variable Sequences by Pearson Correlation Scores

Sequence Number	Variables	Pearson Correlation
1	Carelessness and worker mistakes	0,766
2	Lack of workforce skills	0,686

Suggestions to Minimize the Factors that Influence the Occurrence of Concrete Rebar Waste at the "Apartment X" Project

Suggestions to minimize the factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java, obtained from the results of interviews with 3 experienced construction experts, are summarized as follows:

1. Carelessness and worker mistakes

The contractor should have a good quality control system and supervise the workers involved in concrete rebar properly in order to minimize errors that may result in the occurrence of excessive waste.

2. Lack of workforce skills

The contractor should ensure that all parties involved with concrete rebar, from the engineering side to the field implementer, have the capacity to carry out the work that will be assigned.

CONCLUSION

Based on the findings of the construction material waste research at the "Apartment X" project in Bekasi, West Java, Indonesia, the following conclusions can be drawn:

1. The percentage of concrete rebar waste during the research period was as follows:

a. In several columns work, the percentage data of concrete rebar waste on D10 rebar is 0,51%; D13 rebar is 1,99%; D19 rebar is 16,33%; D22 rebar is 12,33% and D25 rebar is 8,33%.

b. In the partial wall of STP work, the percentage of concrete rebar waste on D13 rebar is 0,57% and D16 rebar is 1,29%.

2. The factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java, are "carelessness and worker mistakes" and "lack of workforce skills".

3. The suggestions to minimize the factors that influence the occurrence of concrete rebar waste at the "Apartment X" project in Bekasi, West Java, are as follows:

a. Carelessness and worker mistakes

The contractor should have a good quality control system and supervise the workers involved in concrete rebar properly in order to minimize errors that may result in the occurrence of excessive waste.

b. Lack of workforce skills

The contractor should ensure that all parties involved with concrete rebar, from the engineering side to the field implementer, have the capacity to carry out the work that will be assigned.

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