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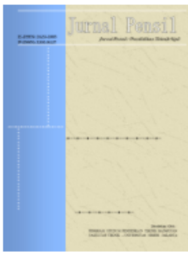
Journal homepage: http://journal.unj.ac.id/unj/index.php/jpensil/index



STUDY ON IMPLEMENTATION OF CONSTRUCTION WASTE MANAGEMENT IN MINIMIZING CONSTRUCTION MATERIAL WASTE

Haryo Aji Kurniawan[1], Fajar Susilowati[2], Ria Miftakhul Jannah[3]*
[1,2,3] Program Studi Teknik Sipil, Fakultas Teknik, Universitas Tidar
Jalan Kapten Suparman 39 Potrobangsan, Magelang Utara, Magelang, Jawa Tengah 56116, Indonesia
[*1]haryoajik.ha@gmail.com, [2]fajar.susilowati@untidar.ac.id, [3]riamifta_@untidar.ac.id

P-ISSN: 2301-8437
E-ISSN: 2623-1085

ARTICLE HISTORY
Accepted:
14 Agustus 2023
Revision:
25 September 2023
Published:
30 Januari 2024

ARTICLE DOI:
10.21009/jpensil.v13i1.37863

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Abstract

The implementation of a building construction project is unavoidable from the emergence of waste material. Construction material waste is defined as something that is over what is required. This study intends to find the application of construction waste management in building construction projects to minimize the waste material. Data was collected using observation, interviews, and distributing questionnaires to 4 building project parties in Central Java using a random sampling method. Data analysis was carried out by descriptive analysis to determine the type and cause of the highest waste material and supported by regression and correlation analysis to assess the application of ways to minimize waste material. The results of data analysis show that the most types of waste material are formwork wood, reinforcing steel, concrete, and cement. The factor causing waste material that most often occurs is the design change factor that comes from the design phase. Based on the analysis, the effort to minimize waste material that is the most influential on it is improving the quality of tool and material management by providing training to construction personnel related to materials construction used.

Keywords: Waste Material, Construction Project, Building

Introduction

The implementation of development in the construction sector in addition to having a positive impact by improving the level of people's welfare also has great potential for environmental damage. The contribution of the construction sector to natural damage includes material extraction, material processing, material distribution, construction processes, land acquisition for development and energy use in building operations (Reza Mahendra et al., 2019). Development of constructions is inseparable from the use of various types of materials. The use of materials in the construction process is what causes materials that can no longer be used in relatively large quantities (Zalaya et al., 2019.). In every realization of a construction project, the emergence of construction waste cannot be avoided, so it can be concluded that construction projects are closely related to construction waste (Widhiawati et al., 2019).

Estimation of waste generated from C&D is the most important part of construction waste management. Quantification of construction waste and taking necessary action to address the issue is necessary for the sustainable development of society. Furthermore, it is important to identify causes of C&D waste generation, strategizing waste recycling and disposal and estimation of the economic value of waste (Islam et al., 2019).

The impact of the construction of the construction project is to produce solid waste which if not handled seriously will endanger the environment (Suprapto & Sri, 2009). A number of aspects where as a source of construction material waste, including concepts, component sources, component management, implementation, residues, and much more (Pertiwi et al., 2019).

This research intends to conduct a study on implementation of construction waste management in building construction projects so that the waste produced can be as minimal as possible. The aim of this research is to identify types of waste materials and the factors that influence them, followed by an explanation of the application of construction waste management in construction projects. This research takes the research object as a building construction project in Central Java.

Waste Material

Waste material is part of the material that is not used in the implementation construction project and not being part of the building. So that the more waste material there is, the less efficient the use of materials in the project (Fajar Sri et al., 2018). It is difficult to give exact figures of construction waste produced on a typical construction site, but it is estimated that it is as much as 30% of the total weight of building materials delivered to a building site (Osmani, 2011).

Construction waste can be interpreted as a material or object that can no longer be used and or is the result of a very large amount of construction implementation process that has an adverse impact on the surrounding environment (Mahendra et al., 2021). Construction and demolition (C&D) waste is characterised by its high volume and weight but with probably the lowest environmental burden (Gálvez-Martos et al., 2018). As such, apart from environmental sustainability, reduced resource excavation and prevention of several environmental hazards as likely results of waste reduction (Ajayi et al., 2017).

A number of aspects where as a source of construction material waste, including concepts, component sources, component management, implementation, residues, and much more. Therefore, an understanding of waste management is needed, including the various types of waste generated during construction and the factors that contribute to material waste (Jusoh et al., 2018). Waste material is waste in the form of residual construction composition and other waste from activities during construction, demolition and land clearing at the beginning of project formation (Putra, 2021).

Type of Waste Material

Residual materials have an influence on the contractor's profit on the construction project. The types of remaining materials can be categorized into two parts, demolition waste and construction waste (Putri et al., 2021). There are 9 types of construction materials that will be observed in this study, including iron, concrete, sand, split stone, bricks, tiles, cement, paint, ceramics, and wood where the source is design, procurement, handling, implementation, residuals, and others (Rachman & Tenriajeng, 2019).

Factors Causing Waste Material

Constructions, demolition and renovation activities during which villages are built into towns, towns into cities and cities into mega cities could be attributed to the constant uptake of waste construction (Akinade et al., 2018). The causes of waste material in a construction project arise from several sources, namely design, procurement, handling, implementation, residuals, and other factors (Devia et al., 2010).

Construction and demolition waste (CDW) is the primary waste stream of gross waste generation in modern society. The amount of CDW grows along with the current worldwide urbanization. China, the United States (US), and the European Union (EU) are the three biggest economies as well as the top three CDW (Zhang et al., 2022).

The use of too many resources, the combination and deepening of the concept of a number of buildings, damage to materials due to errors in handling or shipping, material damage due to weather and inappropriate storage, lack of material data delivered and used, waste from the project office, and excess material in the preparation and completion of work also cause material waste (Putra et al., 2018).

Ways to Minimize the Occurrence of Waste Material

The Construction for Excellence Report of the Construction Industry Review Committee recommended that construction waste should be minimized at source. This recognizes that if we are to significantly reduce the level of construction waste designers should consider waste reduction early in the design stage and throughout the design of a construction project (Baldwin et al., 2009).

Solutions to minimize the occurrence of material waste, including minimizing design changes, providing details and clear drawing information, buying building materials that suit your needs, and others (Iswinarno, 2017).

Construction Waste Management

Waste management encompasses collection, transporting, storage, treatment, recovery and disposal of waste, and is defined as a comprehensive, integrated, and rational system approach towards achievement and maintenance of acceptable environmental quality and support of sustainable development (Hwang & Yeo, 2011).

In planning and realizing sustainable development, the totality of the project team is needed, one of which is by implementing the management of building residues due to the construction stage and building destruction. Building residual management or Waste Management is important to be considered by the construction implementer (in this case the contractor) starting at the time of estimation to implementation in the field. This is done so that the rest of the material can. As little as possible produced so that there is not much accumulation of residual material at the project site and of course can save costs (Suartika Putra, 2021).

Waste in the construction field can be interpreted as a loss or a loss of material resources, time (with regard to labor and equipment) and capital, which is caused by activities that cost money, directly or indirectly, but does not add value to end product for users of construction services(Waty et al., 2018).

The waste management hierarchy is an effective framework that guides to develop waste management planning. The framework provides an integrated approach by which waste management options are considered and becomes a systematic tool for those who create and manage waste. There are several things in the application of construction waste management, namely reduce, reuse, recycle, recover, disposal (Ma'ruf et al., 2017).

To ensure the conservation of natural resources and to reduce the cost and impacts of waste disposal, effective waste management practices must be put in place. This will ensure the flow of construction material in a closed loop to minimise waste generation, preserve natural resources and reduce demand for landfills. To achieve this, effective management strategies such as waste reduction, component reuse and material recycling are needed to divert Construction and Demolition Waste (CDW) from landfills (Akinade et al., 2018).

Research Methodology

This research was conducted in the construction of high-rise buildings of 5 floors or more in Central Java, including the Construction Project of the Outpatient Building and Diagnostic Center of Panti Wilasa Citarum Hospital, the Tidar University Building Construction Project, the Temanggung Hospital Construction Project, and the Semarang Rez Hotel Construction Project.

This research used primary and secondary data. Primary data include research data obtained from questionnaire results supported by observations of activities and conditions in project implementation as well as interviews with parties directly involved in waste materials. Secondary data obtained through literature review and literature study obtained in the form of research variables.

Research Variables

The variables of this study are the type of waste material (Y), the cause of waste material (X1) and how to minimize waste (X2). Table 1 is a variable of the types of waste material from several references, Table 2 is a variable factor causing waste material from several references, and Table 3 is a variable how to minimize material waste from several references. Variable measurement in research using Likert scale which produces interval scale of 5 levels.

Table 1. Variable Type of Waste Material

Variable	Types of Waste Material
Y1	Sand
Y2	Crushed stone
Y3	Reinforcing bar
Y4	Concrete
Y5	Cement
Y6	Wall (brick)
Y7	Formwork wood
Y8	Ceramics
Y9	Mortar

Table 2. Variable Factors Causing Waste Material

Variable	Factors Causing Waste Material
X1.1	Design changes
X1.2	Incomplete design information
X1.3	Product specification selection
X1.4	Errors in contract documents
X1.5	Selection of low-quality products
X1.6	Lack of attention to the dimensions of the material used

Variable	Factors Causing Waste Material
X1.7	Lack of coordination with contractors and lack of knowledge regarding construction
X1.8	Complicated detailed engineering drawing
X1.9	The occurrence of miscommunication in design planning
X1.10	Booking errors, advantages, disadvantages, etc.
X1.11	Wrong when ordering materials, because don't understand the specifications
X1.12	Reservations are only available in bulk
X1.13	buying materials that are not according on qualifications
X1.14	Delivery of non-compliant materials
X1.15	Poor packaging
X1.16	Scattered / wasted materials during travel
X1.17	Damage on the way to/at the project site
X1.18	Material delivered in non-solid / less conditions
X1.19	Disposal or throwing of material
X1.20	Careless dismantling of material before storage in warehouses
X1.21	Incorrect material storage causing damage
X1.22	Careless in mixing, processing and wrong in the use of composition so that it needs replacement
X1.23	Less supervision
X1.24	Errors that are due to workers
X1.25	Incomplete documents at the beginning of formation
X1.26	Changes in material qualifications after implementation occur
X1.27	Accidents of workers in site
X1.28	The use of materials that are not right so they need replacement
X1.29	Foundation positioning techniques
X1.30	Non-working equipment
X1.31	Inaccurate on-site measurements resulting in more capacity
X1.32	wrong when cutting material
X1.33	Remaining material packaging
X1.34	Residual material at the time of use
X1.35	The remaining cutting material can no longer be used
X1.36	Loss by theft
X1.37	Lack of good composition supervision on the project and management planning of the remaining materials
X1.38	Bad weather

Table 3. Variable How to Minimize Material Waste

Variable	How to Minimize the Occurrence of Waste
X2.1	Providing information and image details clearly
X2.2	Provision of training to construction personnel on materials
X2.3	Accurate determination of material specifications
X2.4	Periodic control of the quantity and capacity of the composition accordingly
X2.5	More efficient use of construction equipment
X2.6	Improve the quality of tool and material management
X2.7	Coordinating with owners, contractors, and supervisory consultants
X2.8	Using leftover material for other purposes
X2.9	Shorten the transportation distance of material vehicles in the selection of suppliers close to the construction project
X2.10	Improve the supervisory performance of the project construction manager

Data Processing

The measurement model was evaluated in order to assess the reliability and validity of the measures (Kabirifar et al., 2021).

1. Descriptive Statistics. This analysis is used to describe the profile of respondents, types of waste materials, factors that cause waste materials and how to minimize waste in this study. The description of research data is processed based on the calculation of statistical values, namely the mean / average (Hilgers et al., 2019).
2. Frequency Distribution. Frequency distribution is a list that divides data into a number of classes (Nasution, 2017). The frequency distribution in this study was used to categorize each material waste variable.
3. Regression Analysis. Multiple Linear Regression Analysis is used in finding impacts on every way to minimize waste and the causes of material waste on the types of material waste that occur in construction projects. Benefit Regression Model of Construction Project, After obtaining regression model that has been tested in both validation and validity of the data, the model can be used for contractors in following auction. When contractors bid, they certainly pay attention in order to achieve maximum profit with minimum waste. Regarding limits (range) of waste material, it is expected that contractors can anticipate by producing minimum waste for increase maximum profit. To be achieve minimum waste, risk management at construction is necessary (Megawaty, 2018).
4. Correlation Analysis. Correlation analysis is used to find frequency relationships in ways to minimize waste for high waste. The existence of the relationship is mentioned in the form of numbers which display the strength of the correlation of each two or more variables. The direction is mentioned in the positive and negative correlation (Wahyudi, 2010).

Research Results and Discussion

Respondent Profile

The profiles of respondents in this research are shown in Table 4.

Table 4. Respondent Profile

Gender	**Percentage**
Man	90.32%
Woman	9.68%
Age	**Percentage**
20-30 Years	38.71%
31-40 Years	25.81%
41-50 Years	22.58%
> 50 Years	12.90%
Length of Work	**Percentage**
< 10 Years	51.61%
11-20 Years	25.81%
21-30 Years	12.90%
> 30 Years	9.68%

Research Variable Test

Validity Test

Validity tests aim to test whether the research data is valid based on the research questionnaire instrument which includes indicators of the causes of material waste, and how to handle the remaining material what has happened (Uda et al., 2022). The validity test used in the study is a comparison between the r value of the table and calculate (Wijaya & Huda, 2020). The r-count value (Pearson correlation) with the r-table value for 31 respondents is 0.355. The test results showed that all questionnaire question items were greater than 0.355 so it could be said to be vaild.

Reliability Test

This reliability test uses the Cronbach Alpha technique, this observation is called reliability if the Cronbach alpha number ≥ 0.7 and the significance test is carried out in the level of α = 0.05 (5%) (Dewi, 2018). The test results of all variables have a Cronbach Alpha coefficient exceeding 0.70 so that all questionnaire statements are considered reliable.

Types of Waste Material

The categories of types of waste materials are obtained through descriptive statistical calculations and frequency distribution analysis. The following is a table of waste material categories.

Table 5. Category Waste Material

Types of Waste material	Category
Sand	Low
Crushed stone	Low
Reinforcing iron	Medium
Concrete	Medium
Cement	Medium
Formwork wood	Medium
Mortar	Low
Ceramics	Low
Wall (bricks / light bricks)	Low

Based on Table 5. It can be known that the waste materials are in the medium category, namely formwork wood, reinforcing iron, concrete, cement. While the waste materials are in the low category, namely mortar, walls, ceramics, crushed stone, and sand.

Factors Causing Waste Material

Factors causing material waste come from design, procurement, handling, implementation, residues, and other factors (Devia et al., 2010). After calculation, the recapitulation for the rank and category of factors causing waste material is as follows.

Table 6. Categories of Waste Causing Factors

Causative Factors	Percentage	Category
Design changes	65.16%	High
The details of the image are too complicated	62.58%	High
Incomplete design	62.58%	High
Lack of contractor coordination and lack of knowledge regarding construction	61.94%	High
Changes in material specifications after implementation	61.94%	High
Selection of low-quality products	60.00%	Medium
The occurrence of miscommunication in design planning	59.35%	Medium
Delivery of non-compliant goods	58.71%	Medium
Carelessness when mixing and processing and errors in using materials	58.06%	Medium
Poor supervision	58.06%	Medium

There are 5 factors causing high-category waste materials, namely design changes; the details of the image are too complicated; incomplete design; Lack of contractor coordination and lack of knowledge regarding construction; and changes in material specifications after the implementation takes place; while the other factors causing waste material are in the medium category.

How to Minimize Material Waste

How to minimize material waste is most often done to minimize material waste in building construction projects in Central Java as follows.

Table 7. Categories How to Minimize Material Waste

How to Minimize *Material Waste*	**Percentage**	**Category**
Improve the quality of tool and material management	81.29%	Very often
Improve the supervisory performance of *the project construction manager*	81.29%	Very often
Provision of clear information and image details	80.00%	Very often
More efficient use of construction equipment	80.00%	Very often
Provision of training to construction personnel on materials	78.71%	Often
Periodic checking of the amount and volume of material appropriately	78.71%	Often
Improve coordination from *owners*, contractors, and supervisory consultants	77.42%	Often
Using leftover material for other purposes	76.13%	Often
Shorten material transportation distance by choosing suppliers close to the project	76.13%	Often
Accurate determination of material specifications	74.19%	Often

Based on Table 7, the most frequent way to minimize material waste is to improve the quality of equipment and material management and improve the supervisory performance of project construction managers by the same percentage of 81.29%.

Analysis of Construction Waste Management Application

Regression Analysis

Multiple linear regression analysis is used to determine the effect of frequency of how to minimize waste (X2) and waste causing factors (X1) on the amount of material waste (Y) that occurs.

Table 8. Multiple Linier Regression Analysis Output

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	44.815	14.479		3.095	.006
	X2.1	-1.610	2.314	-.143	-.696	.495
	X2.2	-4.820	1.983	-.478	-2.431	.025
	X2.3	1.679	1.384	.225	1.213	.240
	X2.4	-2.322	1.640	-.300	-1.416	.173
	X2.5	-.820	3.101	-.058	-.264	.794
	X2.6	-7.342	2.478	-.650	-2.963	.008
	X2.7	1.524	1.645	.196	.926	.366
	X2.8	-2.603	2.260	-.311	-1.152	.264
	X2.9	6.726	2.637	.775	2.551	.020
	X2.10	2.377	2.657	.182	.895	.382
	X1	.112	.057	.326	1.985	.062

a. Dependent Variable: *Waste material*

Based on the tests in the Table 8 can be formulated regression model as follows:
$Y = 44.815 - 1.610\, X2.1 - 4.820\, X2.2 + 1.679\, X2.3 - 2.322\, X2.4 - 0.820\, X2.5 - 7.342\, X2.6 + 1.524\, X2.7 - 2.603\, X2.8 + 6.726\, X2.9 + 2.377\, X2.10 + 0.112\, X1 + e$

From the model of the equation can be known the value of the constant is 44.815. It states the state when the dependent variable has not been influenced by the independent variable. If there is no independent variable, the dependent variable does not change.

This study, a negative regression coefficient will be taken which has the opposite meaning so that if the value of how to minimize material waste increases, the number of types of material waste that occurs will decrease. Variables whose regression coefficient is negative are X2.1, X2.2, X2.4, X2.5, X2.6, and X2.8. The most influential variable is variable X2.2 (Provision of training to construction personnel on materials) with a t-table value of -2.963 and a significance value (sig.) 0.008.

Correlation Test

Correlation analysis is used to determine the relationship between the frequency of how to minimize waste to the amount of waste.

Table 9. Output Spearman Rank Correlation Test

Types of Waste Material	How to Minimize Material Waste				
	X2.1	**X2.2**	**X2.5**	**X2.6**	**X2.8**
Sand	0.105	-.540**	-0.118	-0.294	-.378*
Crushed stone	0.175	-0.236	-0.240	-0.045	-0.257
Reinforcing iron	0.001	-0.323	-0.088	-0.343	-0.226
Concrete	-0.298	-0.163	-0.145	-0.199	-0.167
Cement	0.074	-0.354	0.167	-0.339	-0.235
Formwork wood	0.105	-.474**	-0.039	-.526**	-.445*
Mortar	-0.173	-.358*	-.406*	-0.139	-0.343
Ceramics	0.169	-0.331	-0.036	-0.071	-0.260
Wall	-0.300	-0.350	-0.210	-.623**	-0.284

The way to minimize material waste that reduces material waste the most is providing training to construction personnel on materials and improving the quality of tool and material management that has an impact on 3 variables of material waste.

The difference from regression and correlation analysis lies in the variable X2.4 (periodic checking of material quantity and volume) where in regression analysis the variable is influential and in the correlation analysis the variable is not related. These results can be concluded that there are 5 influential and related variables, namely X2.1, X2.2, X2.5, X2.6, and X2.8.

Conclusion

The types of waste materials that often occur in building construction projects in Central Java are in the medium category, namely formwork wood, reinforcing iron, concrete and cement. There are 5 (five) factors causing high-category waste materials, namely design changes, complicated drawing details, incomplete design information, lack of coordination with contractors and lack of knowledge about construction, and changes in material specifications after implementation. How to minimize material waste that reduces material waste the most, namely variable X2.2 (providing training to construction personnel on materials) on sand; cement; and ceramics, and X2.6 (improving the quality of tool and material management) against reinforcing iron; snail wood; and walls.

Further research, can be carried out with research objects other than in Central Java, road construction projects or water buildings, and reviewed from the perspective of planning consultants.

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