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The Main Causes of Waste Materials at Warehouse Construction Project

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Abstract. Material is one of the most important components as it contributes 40-60% to determine the cost of the project, so it plays an indirectly important role to support the success of the project, especially in the cost component. Waste materials in the construction sector can be interpreted as a loss of material resources, time (related to labor and equipment), and capital. This was caused by activities that require cost (money) whether directly or indirectly but it does not affect the final value of the product for construction services users. The purpose of this research is to determine the main causes of the waste materials that most affect the cost. This research was conducted using primary data in the form of a questionnaire with the Relative Importance Index (RII) method with the Statistical Product and Service Solutions (SPSS) program with a significance level of 5% to determine the main cause of the waste materials that most affect the cost. Based on the results of this research, the main causes of waste materials that most affect the cost of a warehouse construction project are inaccurate measurements in the field resulting in excess volume, lack of consideration regarding product dimensions, and using the wrong material so it needs to be replaced.

Keywords: Material; Waste Materials

INTRODUCTION

Material is one of the most important components as it contributes 40-60% to determine the cost of the project, so it plays an indirectly important role to support the success of the project, especially in the cost component. (Ritz, 1994). On the other hand, during the construction of a project, waste materials cannot be avoided. According to (Yeheyis, et al., 2012), more than 75% of the products produced by the construction industry are waste materials that have a residual value and can be recycled, salvaged, and/or reused.

Waste materials in the construction sector can be interpreted as a loss of material resources, time (related to labor and equipment), and capital. This was caused by activities that require cost (money) whether directly or indirectly but it does not affect the final value of the product for construction services users (Waty, et al., 2018). In addition, waste materials construction is defined as something excessive in nature, whether in the form of work or material construction that is leftover/scattered/damaged, so that it cannot be used according to its function (J.R. Illingworth, 1998).

Waste materials construction is not only important from the efficiency point of view but also affects the environment. Waste materials construction can increase 15-30% of municipal solid waste, so minimizing the waste materials is important for construction actors (Brook, 1994). Each year, the volume of waste materials construction always increases, resulting in long-term environmental, economic, and social impacts, as well as a diminishing supply of land. Therefore, the management of waste materials is very important to protect public health and natural ecosystems (Yeheyis, et al., 2012).

Some of the factors that influence the waste materials are inadequate supervision, inadequate work area, inadequate auxiliary equipment, no classification of work fields, ineffective number of workers in a field, and inexperience of the masons. (Prasetyo & Septian, 2010).

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According to the problems, the authors formalize the objectives of this research is to determine the main causes of waste materials that most affect the cost of a warehouse construction project. In addition, the purpose of this research is to reference construction actors to minimize the waste materials by determining the main causes of waste materials that most affect the cost of a warehouse construction project.

RESEARCH METHOD

In this research, data collection techniques are one of the most important factors to support the success of the research. The method used in this research is from primary data by distributing questionnaires. Distributing questionnaires will be given to several respondents including field managers, field supervisors, and field implementers to find out the main causes of waste materials that most affect the costs of a warehouse construction project.

Primary data is obtained through a questionnaire that has been collected, then it will be processed to determine the main cause of the waste materials that most affect the cost of a warehouse construction project.

The main cause of the waste materials will be determined through questionnaire data, where respondents will be given several choices of the most frequently seen causes so that the main cause of the waste materials in the warehouse construction can be identified.

Data analysis to determine the main cause of the waste materials that most affect cost is done by using the validity test and reliability test in advance.

A validity test can be used to measure whether a questionnaire is valid or not. Therefore, the validity test will be used by correlation significance test at the significant level of 0.05 or 5%. The testing technique used for the validation test is to use Bivariate Pearson Correlation (Pearson Moment Product) and Corrected Item-Total Correlation. This analysis was carried out by correlating each item's score with the total score. The total score is the sum of all question items that are significantly correlated with the total score indicating that the question items can provide support in revealing the research.

The formula for Pearson Moment Product Correlation is as follows:

$$r_{xy} = \frac{N(\sum XY) - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)(N\sum Y^2 - (\sum Y)^2)}} \quad (1)$$

where r_{xy} = correlation coefficient, X = score of items, Y = total score of questions, ΣX = total score of items, ΣY = total score of total questions, ΣX^2 = sum of scores of squares of items, ΣY^2 = total score of a square of the total questions, N = number of samples/respondents.

A reliability test can be used to determine whether the measuring instrument is reliable and remains consistent. Reliability is instruments used in research to obtain information that can be trusted as a data collection instrument and can reveal actual information in the field. A questionnaire is reliable if the respondent's answer is consistent or stable over time. The method used to test the reliability is the Cronbach Alpha method.

The formula to find the value Cronbach Alpha is as follows:

$$r_{11} = \left[\frac{k}{k-1}\right]\left[1 - \left[\frac{\sum \delta_b^2}{\sum \delta_t^2}\right]\right] \quad (2)$$

where r_{11} = reliability coefficient (Cronbach Alpha value), k = number of items, $\sum \delta_b^2$ = number of item variance, $\sum \delta_t^2$ = total variance of the total score.

If the value of the r calculated is greater (≥) than the value of the r table, the data will be valid. A construct or variable is reliable if it provides a value of Cronbach Alpha >0.60 (Ghozali, 2016).

After the validity and reliability tests are carried out, the Relative Importance Index (RII) method is calculated to determine the ranking of the main causes of waste materials.

Relative Importance Index (RII) is an analysis carried out to process raw data obtained from the results of a questionnaire to determine the ranking of certain factors. RII will be calculated on each factor or statement (i) based on the respondent's answer and calculated using an equation.

The formula for finding the value of RII is as follows:

$$RII_i = \frac{n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5 + 6n_6}{A\,N} \quad (3)$$

where RIIi = Relative Importance Index, n_1 = number of respondents who gave a score of 1, n_2 = number of respondents who gave a score of 2, n_3 = number of respondents who gave a score of 3, n_4 = number of respondents who gave a score of 4, n_5 = number of respondents who gave a score 5, n_6 = the number of respondents who gave a score of 6, A = the highest score, N = the number of samples/respondents.

The research variable can be found in Table 1.

TABLE 1. Research Variable Table

Variable	Causes	Sources
Design	1. Error in contract documents 2. Incomplete contract documents 3. Design changes 4. Choose product specifications 5. Choose low-quality product 6. Lack of consideration regarding product dimensions 7. Designers are not familiar with other types of product 8. Complicated detailing 9. Inadequate image information 10. Lack of coordination with contractors and lack of knowledge about construction	(Bossink & Brouwers, 1996), (Gavilan & Bernold, 1994), (Koskela, 1992)
Procurement	11. Order faulty, advantages, disadvantages, etc 12. Orders cannot be placed in small quantities 13. Purchase of material does not conform to specifications 14. Supplier sends goods not according to specifications 15. Poor packaging cause damage during transit	(Bossink & Brouwers, 1996), (Gavilan & Bernold, 1994), (Koskela, 1992)
Handling	16. Material is not packaged properly 17. Discard/disposing material 18. The material sent is in a non-solid/less solid state 19. Improper storage of material cause damage 20. Careless handling of material at the time of unloading to put into a warehouse 21. Material damage due to transportation to/at the project site	(Bossink & Brouwers, 1996), (Gavilan & Bernold, 1994), (Koskela, 1992)
Implementation	22. Error caused by labor 23. Equipment that does not work properly 24. Bad weather 25. Worker accident at the field 26. Using the wrong material so it needs to be replaced 27. Method for laying the foundation 28. The amount of material required is unknown due to poor planning 29. Information on the type and size of the material that will be used is late to be submitted to the contractor 30. Carelessness in mixing, processing, and error in the use of material that needs to be replaced 31. Inaccurate measurements in the field resulting in excess volume	(Bossink & Brouwers, 1996), (Gavilan & Bernold, 1994), (Koskela, 1992)
Residual	32. The remaining cutting material cannot be used anymore 33. Error when cutting material 34. Error ordering goods due to not mastering specifications 35. Packaging 36. Waste materials due to the use process	(Bossink & Brouwers, 1996), (Gavilan & Bernold, 1994), (Koskela, 1992)
Attitude	37. Lack of incentives affecting employee loyalty 38. Hesitate in an attempt to reduce waste materials that cause a lack of motivation 39. Lack of knowledge about waste materials such as how to reduce and responsibility for waste materials	(Budiadi, 2008), (Koskela, 1992)

TABLE 1. Research Variable Table (continued)

Variable	Causes	Sources
Subjective Norm	40. Pragmatic culture 41. Feelings of unfairness that affect worker satisfaction 42. Waste materials are the last priority 43. Lack of management commitment 44. Unclear policies that affect worker satisfaction	(Budiadi, 2008)
Behavior Control	45. The poor process results in the wrong manufacture 46. Inadequate waste materials facilities	(Budiadi, 2008), (Koskela, 1992)
Etc	47. Loss of material due to theft 48. Poor control of materials in the project and management planning of waste materials	(Bossink & Brouwers, 1996), (Gavilan & Bernold, 1994)

RESULTS

The test is carried out based on 9 predetermined variables. Based on the validity test that has been carried out, it can be concluded that 8 of the 48 statements are invalid because the value of r count (≤) r table, while the reliability test shows that N of items as many as 40 questions are reliable because the calculated r value is obtained > 0.60, it can be concluded that the 40 questions have passed the validity and reliability tests.

The variables that passed the validity and reliability test can be found in Table 2.

TABLE 2. Variable That Passed The Validity and Reliability Tests

Variable	Causes
Design	5. Choose low-quality product 6. Lack of consideration regarding product dimensions 7. Designers are not familiar with other types of product 8. Complicated detailing 10. Lack of coordination with contractors and lack of knowledge about construction
Procurement	13. Purchase of material does not conform to specifications 14. Supplier sends goods not according to specifications 15. Poor packaging cause damage during transit
Handling	16. Material is not packaged properly 17. Discard/disposing material 18. The material sent is in a non-solid/less solid state 19. Improper storage of material cause damage 20. Careless handling of material at the time of unloading to put into a warehouse 21. Material damage due to transportation to/at the project site
Implementation	22. Error caused by labor 23. Equipment that does not work properly 24. Bad weather 25. Worker accident at the field 26. Using the wrong material so it needs to be replaced 27. Method for laying the foundation 28. The amount of material required is unknown due to poor planning 29. Information on the type and size of the material that will be used is late to be submitted to the contractor 30. Carelessness in mixing, processing, and error in the use of material that needs to be replaced 31. Inaccurate measurements in the field resulting in excess volume

TABLE 2. Variable That Passed The Validity and Reliability Tests (continued)

Variable	Causes
Residual	33. Error when cutting material 34. Error ordering goods due to not mastering specifications 35. Packaging 36. Waste materials due to the use process
Attitude	37. Lack of incentives affecting employee loyalty 38. Hesitate in an attempt to reduce waste materials that cause a lack of motivation 39. Lack of knowledge about waste materials such as how to reduce and responsibility for waste materials
Subjective Norm	40. Pragmatic culture 41. Feelings of unfairness that affect worker satisfaction 42. Waste materials are the last priority 43. Lack of management commitment 44. Unclear policies that affect worker satisfaction
Behavior Control	45. The poor process results in the wrong manufacture 46. Inadequate waste materials facilities
Etc	47. Loss of material due to theft 48. Poor control of materials in the project and management planning of waste materials

After the validity and reliability tests have been carried out, the Relative Importance Index (RII) method is calculated to determine the ranking of the main causes of the waste materials.

The data from the calculation of the Relative Importance Index (RII) method can be found in Table 3.

TABLE 3. Relative Importance Index (RII)

Ranking	Causes	RII Value	Importance Level
1	Statement 31	0.917	Very High
2	Statement 6	0.912	Very High
3	Statement 26	0.891	Very High
4	Statement 10	0.875	Very High
5	Statement 13	0.870	Very High
6	Statement 33	0.870	Very High
7	Statement 28	0.865	Very High
8	Statement 30	0.865	Very High
9	Statement 48	0.865	Very High
10	Statement 22	0.859	Very High
11	Statement 45	0.854	Very High
12	Statement 19	0.849	Very High
13	Statement 34	0.849	Very High
14	Statement 5	0.833	Very High
15	Statement 7	0.818	Very High
16	Statement 17	0.807	Very High
17	Statement 20	0.802	Very High
18	Statement 47	0.802	Very High
19	Statement 14	0.792	High
20	Statement 21	0.787	High
21	Statement 16	0.781	High
22	Statement 8	0.776	High
23	Statement 29	0.776	High
24	Statement 39	0.771	High
25	Statement 43	0.766	High
26	Statement 46	0.766	High

TABLE 3. Relative Importance Index (RII) (continued)

Ranking	Causes	RII Value	Importance Level
27	Statement 23	0.729	High
28	Statement 27	0.724	High
29	Statement 15	0.719	High
30	Statement 36	0.703	High
31	Statement 38	0.703	High
32	Statement 42	0.693	High
33	Statement 44	0.688	High
34	Statement 18	0.682	High
35	Statement 24	0.682	High
36	Statement 37	0.667	High
37	Statement 40	0.651	High
38	Statement 41	0.646	High
39	Statement 35	0.630	High
40	Statement 25	0.625	High

CONCLUSION

Based on the results of research that has been done, the following conclusions are the main causes of waste materials that most affect the cost of a warehouse construction project are inaccurate measurements in the field resulting in excess volume, lack of consideration regarding product dimensions, and using the wrong material so it needs to be replaced.

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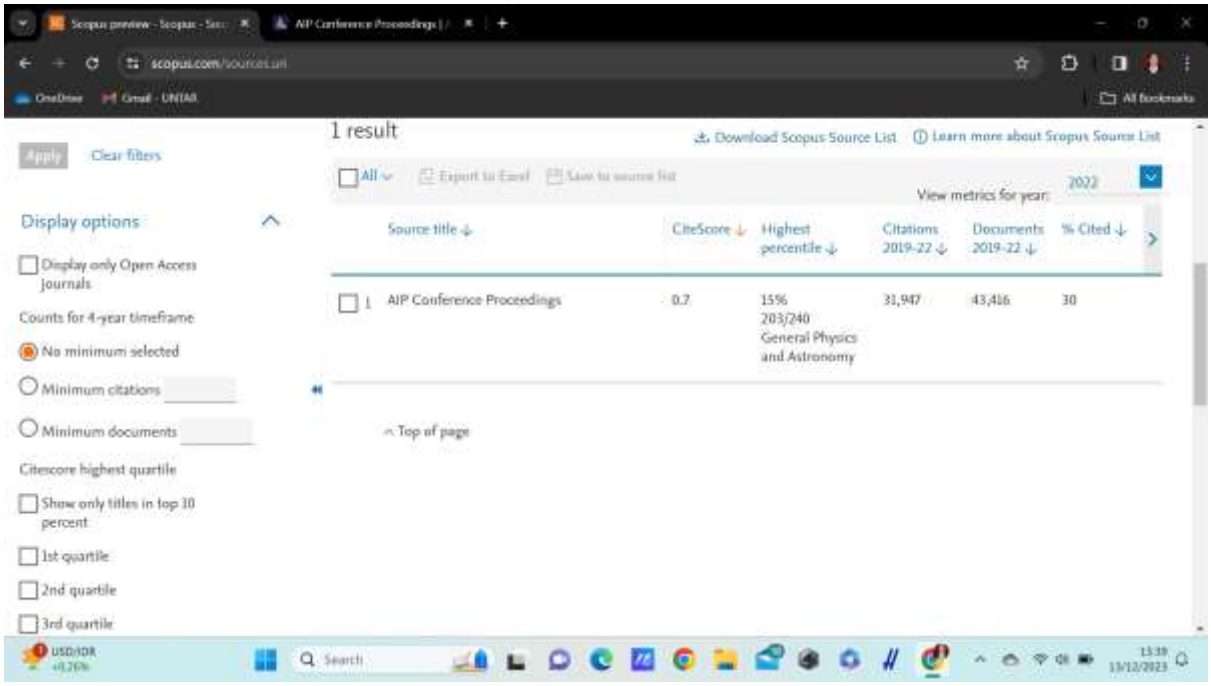
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