Case study of waste material 2 development projects

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Abstract. We can interpret the waste material in construction as loss or loss of material resources, time (by looking at labor and equipment), and also capital, this is caused by activities that require costs, either directly or indirectly, but do not add value at all. construction service products. This research compares the material waste that occurs in 2 project case studies, namely the XYZ factory construction project, and the supermarket building project in Jakarta, and compares the causes of material waste in the two projects. The research methodology is by obtaining secondary data from each project and conducting a questionnaire to find out the comparison of the causes of material waste in the two projects. The most waste in the construction of the XYZ factory was: column work at 34%, the second largest was floor slab work at 10% and the third rank was 6% for ground slab main building work while the most supermarket waste building was Steel structure with a percentage of material remaining 14.5765%, concrete Fc 32 F/A with a percentage of remaining material of 11.5912% and iron in diameter 25 with a percentage of remaining material of 9.1921%. The causes of waste in the two projects are different from one another. Even though there are 3 similarities in the causes of waste material.

1 Introduction

In general, the use of materials will cause a lot of waste material that has been estimated in construction projects [1], meaning that waste material is a very urgent problem in Felixius and Waty's research [2]. We can interpret the remaining material in construction as loss or loss of material resources, time (by looking at labor and equipment), and also capital, this is caused by activities that require costs, either directly or indirectly, but do not add value at all. in construction service products [3]. Material is one of the important components that have a fairly close influence on the cost of a project, so with the presence of a large enough remaining construction material, it is certain that there will be swelling in the financing sector [4] Material as one of the components that has a contribution of 40 % to 60% of the total project cost [5]. In every implementation of a building construction project, the appearance of residual material is unavoidable [6]. Waste in construction can be interpreted as a loss or loss of various resources, namely material, time (related to labor and equipment), and capital, which is caused by activities that require costs directly or indirectly but do not add value to the final product for service users [7]. Research conducted by Bossink and Brouwers (1996) in the Netherlands focuses on preventing the increase of waste materials in the future. The main goal is to reduce the use of non-renewable materials. Provide encouragement to use renewable materials and secondary resources. Examples of secondary materials are leftover materials from the results of construction

and demolition which can be reused as raw materials for production in new construction projects [8].

The research objectives are:

- 1. Knowing the comparison of waste material calculations for 2 project studies, namely the construction of factories and supermarket buildings.
- 2. Knowing the comparison of the causes of waste material in 2 project studies, namely the construction of factories and supermarket building.

2 Method

The research methodology uses Pareto diagrams which are used to calculate the waste that occurs in factory Construction and Supermarket Building. Construction and uses the Relative Importance Index method to determine the causes of material waste in the two projects after the questionnaires are validated and reliability is carried out with the SPSS application.

3 Result and discussion

3.1 Case study 1: waste material construction of XYZ factory

The first case study is a factory construction project that has been completed around 2021 with results using Pareto which can be seen in Fig. 1.

All work data were collected and analyzed using a Pareto chart, 11 works with a waste rate above 1% and

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15 jobs with a waste below 1% were obtained. Of the 11 most wastes, the 3 highest waste materials were obtained, namely column work by 34% which was caused by the number of connections when working on

the column. Furthermore, for floor slab work it was 10% and the third rank was 6% for ground slab main building work [9].



Fig. 1. Pareto diagram for XYZ plant development.

3.2 Case study 2: supermarket building waste material

From the Pareto diagram Fig. 2 can be seen that the 10 items of residual value with the largest to the smallest

percent are: steel structure, concrete f'c 32 F/A, steel dia, 25, Steel dia, 16, steel diameter 10, steel dia. 13, steel dia. 32, concrete fc 32 NON F/A, ex Samson liquid floor hardener, and f'c 55 concrete. The highest percentage was in steel structures (14.57%) and the smallest was in fc' 55 concrete (2.87%) [10].



Fig. 2. Pareto diagram of remaining materials for the construction of a supermarket building.

Of the 10 largest materials (Table 1), the three largest were taken and the causes were determined as follows [10]:

- 1. The cause of the remaining material on the steel structure is due to cutting errors.
- 2. The cause of the remaining f'c 32 F/A concrete material is when the concrete reinforcement is carried out beyond a predetermined limit so it must be broken down.
- 3. The cause of the remaining 25-diameter iron material is due to cutting errors.

3.3 Case study 1: main causes of overall material leftover XYZ plant

Taking the 3 main causes as a whole aim so that each of us knows the main causes of any remaining materials that affect the project. Questionnaire result data has been analyzed using RII and has been sorted in Table 2.

 Table 1. The 10 most waste materials for the supermarket building construction project.

Material	Cost Waste	%
	Material	
Steel Structure	1.200.180.000,00	14,576
Concrete fc 32 F/A (kg)	954.382.250,00	11,591
Steel Dia 25 (m ³)	756.849.491,00	9,192
Steel Dia 16 (kg)	728.159.870,00	8,843
Steel Dia 10 (kg)	663.126.169,00	8,053
Steel Dia. 13 (kg)	592.733.313,00	7,198
Steel Dia. 32 (kg)	580.665.553,00	7,052
Concrete fc 32 NON F/A (m ³)	538.480.000,00	6,539
Liquid Floor Hardener ex Samson (m ²)	346.876.464,00	4,212
Concrete fc 55 (m ³)	236.412.000,00	2,871

Table 2. Rating RII causes major waste materials.

Rank	RII	Source	Importance Level
1	0.844	Statement 10	Very High
2	0.811	Statement 6	Very High
3	0.794	Statement 16	High
4	0.794	Statement 23	High
5	0.794	Statement 25	High
6	0.794	Statement 28	High
7	0.788	Statement 17	High
8	0.788	Statement 31	High
9	0.755	Statement 13	High
10	0.755	Statement 21	High
11	0.755	Statement 26	High
12	0.755	Statement 27	High
13	0.750	Statement 12	High
14	0.750	Statement 22	High
15	0.744	Statement 11	High
16	0.744	Statement 24	High
17	0.738	Statement 29	High
18	0.722	Statement 34	High
19	0.716	Statement 14	High
20	0.705	Statement 2	High
21	0.705	Statement 18	High
22	0.705	Statement 37	High
23	0.694	Statement 15	High
24	0.688	Statement 33	High
25	0.677	Statement 35	High
26	0.666	Statement 1	High
27	0.650	Statement 4	High
28	0.627	Statement 36	High
29	0.622	Statement 8	High
30	0.605	Statement 5	High
31	0.583	Statement 30	Moderate

The design source data from RII is sorted, it can be seen that statement 10 is ranked 1st with RII 0.844 and a very high level of importance, which means that statement 10 has a great influence on overall waste. Statement 10 is "Lack of coordination with contractors and lack of knowledge about construction" [9].

Ranking second after the design source data from RII is sorted, it can be seen that statement 6 with RII is 0.811 and the level of importance is very high, which means statement 6 is very influential on the waste as a whole. Statement 6 is "Not paying attention to the size of the product used" [9].

Statement 16 is ranked third and has an RII value of 0.794 and a high level of importance, which means statement 16 is very influential on the overall waste. The content of statement 16 is "Inadvertent handling of material during unloading to be put into the warehouse"[9]. From this data, the 10 best RII ratings are listed in Table 3.

3.4 Case study 2: causes of material waste overall supermarket building project category

The following is the relative importance index ranking method for the entire category.

From Table 4, the relative importance index values of all categories have been sorted from the largest to the smallest. The first rank is design changes with a relative importance index value of 0.875 and the importance level is very high. The second rank is the amount of material needed is unknown due to imperfect planning with the relative importance index value is 0.869 and the importance level being very high. The third rank is ordering errors, excesses, shortages, etc. with a relative importance index value of 0.866 and a very high level of importance. The ranking results are grouped into the 10 largest ratings as shown in Table 5.

 Table 3. The 10 biggest RII rankings of factory construction waste [9].

Rank	RII	Source	Importance
			Level
1	0.844	Lack of coordination with contractors and lack of knowledge about construction	Very High
2	0.811	Pay less attention to the size of the product used	Very High
3	0.794	Careless handling of materials during unloading to be put into the warehouse	High
4	0.794	Equipment not working properly	High
5	0.794	Field work accident	High
6	0.794	The amount of material required is unknown due to imperfect planning	High
7	0.788	Improper storage causes damage	High
8	0.788	Measurements in the field are not accurate resulting in excess volume	High
9	0.755	Purchase of materials that do not comply with specifications	High
10	0.755	Handling is not be careful at the moment material disassembly to put in in the warehouse	High

3.5 Causes of material waste

3.5.1 Analysis of the causes of waste material for the construction of the XYZ plant

Analysis of the causes of waste material for the construction of the XYZ factory are:

- 1. Lack of coordination with contractors and lack of knowledge about construction. Lack of coordination with contractors, causing errors in ordering goods which cause waste, also contractors or consultants who are less knowledgeable about construction, causing errors that result in waste material.
- 2. Pay less attention to the size of the product used. Lack of attention to the size of the product used results in an ordering error which results in waste due to inappropriate product sizes such as in ceramic work.
- 3. Careless handling of materials during uploading to be put into the warehouse. When putting goods into the Warehouse, those who are not careful during

unloading cause the goods to be damaged or broken, causing reordering which results in waste material on the project.

 Table 4. Rating (RII) for the Overall Supermarket Category

 [10].

Rank	RII	Variable	Importance Level
1	0.875	Statement X1.3	Very high
2	0.869	Statement X4.7	Very high
3	0.866	Statement X2.1	Very high
4	0.866	Statement X4.10	Very high
5	0.856	Statement X5.2	Very high
6	0.846	Statement X2.3	Very high
7	0.836	Statement X9.2	Very high
8	0.833	Statement X1.6	Very high
9	0.833	Statement X5.3	Very high
10	0.823	Statement X1.7	Very high
11	0.823	Statement X5.1	Very high
12	0.820	Statement X4.5	Very high
13	0.816	Statement X1.10	Very high
14	0.816	Statement X4.9	Very high
15	0.797	Statement X3.2	High
16	0.781	Statement X1.9	High
17	0.777	Statement X8.1	High
18	0.774	Statement X1.4	High
19	0.774	Statement X4.1	High
20	0.751	Statement X4.8	High
21	0.745	Statement X1.1	High
22	0.745	Statement X3.6	High
23	0.735	Statement X2.4	High
24	0.732	Statement X6.3	High
25	0.728	Statement X3.3	High
26	0.722	Statement X3.4	High
27	0.718	Statement X5.5	High
28	0.705	Statement X1.2	High
29	0.699	Statement X3.1	High
30	0.683	Statement X1.5	High
31	0.679	Statement X7.4	High
32	0.673	Statement X2.5	High
33	0.669	Statement X4.2	High
34	0.669	Statement X7.5	High
35	0.650	Statement X7.1	High
36	0.647	Statement X8.2	High
37	0.640	Statement X6.2	High
38	0.633	Statement X1.8	High
39	0.624	Statement X7.3	High
40	0.601	Statement X3.5	High
41	0.598	Statement X4.3	Moderate
42	0.555	Statement X6.1	Moderate
43	0.552	Statement X4.6	Moderate
44	0.545	Statement X9.1	Moderate
45	0.539	Statement X5.4	Moderate
46	0.526	Statement X7.2	Moderate
47	0.483	Statement X4.4	Moderate
48	0.421	Statement X2.2	Moderate

- 4. Equipment that does not work properly. Equipment that is not functioning properly causes work errors that result in rework or demolition because the tool is not functioning properly.
- 5. Work accidents in the field. Work accidents in the field result in the death of workers or work being hampered because work must be temporarily stopped so that it can cause job changes which can cause waste to occur.

6. The amount of material required is not known due to imperfect planning. The amount of material needed is unknown because imperfect planning causes work changes in the form of changes in detail drawings and changes in other drawings so that the amount of material needed is not known exactly.

Rank	RII	Variable	Importance Level
1	0.875	Design changes	Very high
2	0.869	The amount of material required is not known due to imperfect planning.	Very high
3	0.866	Order errors, excess, shortage, and so on.	Very high
4	0.866	Field measurements are not accurate resulting in excess volume	Very high
5	0.856	Error while cutting material	Very high
6	0.846	Purchase of materials that do not comply with specifications	Very high
7	0.836	Poor material control on the project and management planning for the remaining material	Very high
8	0.833	Lack of incentives affecting employee loyalty	Very high
9	0.833	Error ordering goods, because it does not master the specifications	Very high
10	0.823	Designers are not familiar with other types of products	Very high

 Table 5. The 10 biggest RII rankings of supermarket building construction waste [10].

7. Improper storage cause damage. Improper storage of materials can cause damage to materials such as cement which can cause cement to harden resulting in an increase in cement volume which causes waste which causes waste.

- 8. Measurements in the field are not accurate resulting in excess volume. Inaccurate measurements in the field cause excess volume of material which causes changes resulting in waste.
- 9. Purchase of materials that do not comply with specifications. Purchasing materials that are not in accordance with specifications results in the purchase of re-materials resulting in losses in a project.
- 10. Damage due to transportation to/at the project site. Damage due to transportation to and at the project site causes material to be wasted or material sent needs to be recalculated or material is scattered so that an additional volume of material is needed.

3.5.2 Analysis of 10 causes of waste material in supermarket building projects

Analysis of the 10 biggest causes of waste material in Supermarket Building Projects are:

1. Design changes. Design changes are the most common thing that occurs because with an unclear initial design, the consultant completes and improves the design resulting in changes in both details and the entire design, which affects the amount of material needed.

- 2. The amount of material required is unknown due to imperfect planning. The amount of material needed is unknown because imperfect planning causes work changes in the form of changes in detail drawings and changes in other drawings so that the amount of material needed is not known exactly.
- 3. Order errors, excess, shortage, and so on. Ordering errors in the field result in excess material, or also a shortage of material caused because the material ordered is not as expected so that it turns into waste which results in leftover material.
- 4. Inaccurate field measurements resulting in excess volume. Measurements in the field are not accurate resulting in excess volume of material that has been determined.
- 5. Errors when cutting material. Errors when cutting the material result in leftover material that cannot be used anymore, such as in concrete iron which results in steel structure and fc'32 concrete work.
- 6. Purchase of materials that do not comply with specifications. Purchasing materials that are not in accordance with specifications results in the purchase of re-materials resulting in losses in a project.
- 7. Poor material control in the project and management planning for the remaining materials. implementation of work on the project, as well as material management planning for the remaining material on a project that is inappropriate and bad resulting in material waste on the project.
- 8. Measurements in the field are not accurate resulting in excess volume. The lack of incentives also affects employee loyalty, so incentives are really needed that are properly managed so as to increase employee loyalty which can reduce the waste that occurs.
- 9. Error ordering goods, because it does not master the specifications. There was an error in ordering goods because they did not master the specifications which resulted in repeated ordering of goods so that the old goods were not used because the logistics sector did not master the specifications.
- 10. Designers are not familiar with other types of products. Designers do not know other types of products well which results in having to order or buy only known goods because other products may be of the same type but the designer does not know about them resulting in waste because the goods that arrive can be excessive or reduced depending on the existing stock.

3.5.3 Comparison of factory waste material and supermarket buildings are in terms of the most waste material

In the construction of most waste factories column work by 34%. Then on the floor slab work by 10% and the

third rank by 6% on the ground slab main building work. The biggest cause of column work waste is the number of connections [9] which can be seen in Table 6.

Table 6. Comparison table of 2 project waste material cas	e
studies.	

Number	Factory project	Supermarket building
1	Most waste material	Most waste material
1.1	Column	Steel structure
1.2	Floor slab	Concrete fc 32
1.3	Grand floor slab	Diameter reinforcing steel. 25
2	Causes	Causes
2.1	Lack of coordination with contractors and lack of knowledge about construction	Design changes
2.2	Lack of attention to the size of the product used,	The amount of material required is unknown due to imperfect planning.
2.3	Careless handling of materials during unloading to be put into the warehouse	Order errors, excess, shortage and so on

In the supermarket building, the most waste is steel structure with a percentage of remaining material of 14.576%, concrete fc 32 F/A with a percentage of remaining material of 11.591%, and diameter reinforcing steel 25 iron with a percentage of remaining material of 9.192% which can be seen in Table 6.

The cause of the most waste in steel structures and iron diameter 25 is material cutting errors and the biggest cause of waste in fc 32 concrete is when concrete reinforcement is carried out beyond a predetermined limit so it must be broken into [10].

The main causes of waste material are factory, construction projects and supermarket building projects. The main cause of the remaining material from the XYZ factory are, which can be seen in Table 6 as follows:

- 1. Lack of coordination with contractors and lack of knowledge about construction.
- 2. Lack of attention to the size of the product used.
- 3. Careless handling of materials during uploading to be put into the warehouse.

The main causes of material waste in supermarket building projects are, which can be seen in Table 6 as follows:

- 1. Design changes.
- 2. The amount of material required is unknown due to imperfect planning.
- 3. Order errors, excess, shortage, and so on.

From the results of the discussion above, the comparison of waste material in factory construction projects and supermarket building projects is that there are similarities for the two causes of waste material which are the causes of waste in the two projects, namely:

1. Field measurements are inaccurate resulting iin excess volume. Measurements in the field are not

accurate resulting in excess volume of material that has been determined.

- 2. Purchase of materials that do not comply with specifications. Purchasing materials that are not in accordance with specifications results in the purchase of re-materials resulting in losses in a project.
- 3. The amount of material needed is unknown due to imperfect planning. The amount of material needed is unknown because imperfect planning causes work changes in the form of changes in detail drawings and changes in other drawings so that the amount of material needed is not known exactly.

There are differences in the comparison of waste material, namely:

- 1. Lack of coordination with contractors and lack of knowledge about construction, is a rating.
- 2. Less attention to the size of product used.
- 3. Careless handling of materials during uploading to be put into the warehouse.
- 4. Design changes.
- 5. Order errors, excess, shortage and so on.
- 6. Error when cutting the material.
- 7. Equipment that does not work properly.
- 8. Lack of incentives affecting employee loyalty.
- 9. Errors in ordering goods, because they do not master the specifications.
- 10. Designers are not familiar with other types of products.
- 11. Improper storage causes damage.
- 12. Damage due to transportation to/at the project site.
- 13. Work accident in the field.
- 14. Equipment that does not work properly.

4 Conclusion

4.1 Comparison of factory waste material and supermarket buildings are: in terms of the most waste material

In the construction of most waste factories column work by 34%. Then on the floor slab work by 10% and the third rank by 6% on the ground slab main building work. The biggest cause of column work waste is the number of connections.

In the supermarket building the most waste is Steel structure with a percentage of remaining material of 14.576%, concrete f'c 32 F/A with a percentage of remaining material of 11.591% and diameter reinforcing steel 25 with a percentage of remaining material of 9.192%.

The cause of the most waste in steel structures and iron diameter 25 is material cutting errors and the biggest cause of waste in f'c 32 concrete is when concrete reinforcement is carried out beyond a predetermined limit so it must be broken.

4.2 The main causes of waste material are factory construction projects and supermarket building projects

The main cause of the rest of the factory material are:

- 1. Lack of coordination with contractors and lack of knowledge about construction.
- 2. Pay less attention to the size of the product used.
- 3. Careless handling of materials during unloading to be put into the warehouse.
- The main cause of material waste of material waste in supermarket building projects are:
- 1. Design changes.
- 2. The amount of material required is unknown due to imperfect planning.
- 3. Order errors, excess, shortage, and so on.

There are similarities in the comparison of waste from the 10 biggest causes of waste from each project, namely:

- 1. Field measurements are inaccurate resulting in excess volume.
- 2. Purchase of materials that do not comply with specifications.
- 3. The amount of material needed is unknown because of imperfect planning.

There are differences in the 10 biggest causes of material waste from each project, namely:

- 1. Lack of coordination with contractors and lack of knowledge about construction, is a rating.
- 2. Less attention to the size of product used.
- 3. Careless handling of materials during uploading to be put into the warehouse.
- 4. Design changes.
- 5. Order errors, excess, shortage and so on.
- 6. Error when cutting the material.
- 7. Equipment that does not work properly.
- 8. Lack of incentives affecting employee loyalty.
- 9. Errors in ordering goods, because they do not master the specifications.
- 10. Designers are not familiar with other types of products.
- 11. Improper storage causes damage.
- 12. Damage due to transportation to/at the project site.
- 13. Work accident in the field.
- 14. Equipment that does not work properly.

5 Suggestion

Suggestions from the conclusions above are pay more attention to the 6 main causes of waste material for factory and building projects, namely:

- 1. Lack of coordination with contractors and lack of knowledge about construction.
- 2. Pay less attention to the size of the product used.
- 3. Damage due to transportation to/at the project site.
- 4. Design changes.

- 5. The amount of material required is unknown due to imperfect planning.
- 6. Order errors, excess, shortage, and so on.

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