Assessing Waste Problems of Low Cost Housing Development Process Using Waste Assesment Model (WAM)

Nurlaelah[1], Jati Utomo DH[2], Rusdi HA[3], Dian Gustina[1], Halimah Tunafiah[1], Ahmad Muhammad Thantawi[1], Arman Jayady[1]

[1] Departement of Civil Engineering, Faculty of Engineering, Persada Indonesia University YAI, Jakarta; nurlaelah_73@ymail.com,
[2] Departement of Civil Engineering, Faculty of Engineering, Diponegoro University, Semarang 50275, Indonesia; jati.hatmoko@ft.undip.ac.id
[3] Departement of Civil Engineering, Faculty of Engineering, Lambung Mangkurat University, South Kalimantan; rusdi.h.ataf@gmail.com Universitas Lambung Mangkurat; rusdi.h.ataf@gmail.com

Abstract. Currently, the identification and elimination of seven types of waste (Overproduction, Inventory, Defect, Motion, Transportation, Processing, Waiting) in the house construction process, especially in low-cost housing, plays a role in the successful implementation of the Lean Construction concept. This is considered important considering that the developer rarely performs documentation of determining the most significant and frequent waste. So that the contractor does not focus on the type of waste that must be prioritized for reduction / elimination, so that a more efficient and effective development process occurs.
The purpose of this research is to determine the ranking of the seven types of waste that often occur using the Waste Assessment Model (WAM) method including the Waste Relationship Matrix (WRM) and the Waste Assessment Questionare (WAQ). This method is considered superior because it considers the relationship between one waste type and another.
From the determination of WAM in 4 (four) low cost housing projects, the type of waste Defect occupies the highest ranking with a percentage of 21%, followed by Motion which is 18%, Waiting 16%, Overproduction 13%, Inventory 12% , Processing 11% and the smallest type of waste is Transportation, which is 9%. From these data, it can be determined the priority of waste which must be taken immediately by reducing action in the development process is the first ranked waste Defect, followed by the second ranked waste Motion, to the last ranked waste Transportation.

Key Word: *Assesment, Waste, Waste Assesment Model* (WAM), *Waste Relationship Matrix* (WRM), *Waste Assesmen Questionare* (WAQ)

1. Introduction

According to Real Estate Indonesia (REI) data for 2017, as many as 3700 developers (70 percent of REI members), both large and small developers have participated to build low-cost housing at low prices and subsidized throughout Indonesia, including regions. -remote area. This simple housing is intended for low-income / low-cost communities, so that REI continues to strive to increase the construction of houses targeting this class, given the high interest of the community to own them, such as housing A, B, C and D.

These four housing estates are located in the Bekasi West Java area and were built by different developers. In carrying out the construction of houses for consumers, the developer appoints a contractor in accordance with the specified Work Order (SPK). However, there were many problems that occurred in the construction process. According to data from the Indonesian Consumers Foundation (YLKI) in 2018, out of 60 (sixty) complaints in the housing sector, the development process is the most complained of. The problem with the construction process in question is that housing construction is not clear in

terms of the completion time. There have even been complaints that the development process has not been executed for a certain period of time, according to the developer's promise. In the scope of the project in the field, it is assumed that there has been waste in the construction process carried out by the contractor.
The term waste is used to refer to activities that do not add value (Non Value Added Activities / NVA) in the concept of lean thinking [1]. NVA is a part of activities in the production flow other than activities that bring value (Value Added / VA) [2]. In the context of the construction industry, waste has been identified as a problem that has a negative impact on matters related to design variations. Therefore, activities to reduce waste are a very significant opportunity to be carried out by construction stakeholders [3].

According to Ohno as the inventor of the Toyota Production System theory in [4], there are seven types of waste in a series of production processes in the manufacturing industry, namely: 1. Over production, 2. Waiting time (delay), 3. Excessive transportation, 4. Inappropriate processing, 5. Excessive inventory, 6. Unnecessary motion, 7. Defect. Ohno's idea was later introduced and adopted in the construction industry. [5] stated that in the context of the construction industry, it is important to identify and define the seven wastes above, mainly related to the production process. Furthermore, the seven types of construction waste are then defined by [6]:
1. Defect is the product that is not according to specifications
2. Overproduction is producing in larger quantities and faster than needed.
3. Waiting is waiting because of weak management, planning and monitoring of materials and work flow.
4. Inventory is testing, equipment, data storage, process inventory, materials and supplies more than necessary
5. Motion is unnecessary movement of operators from one task to another, or from one place to another
6. Transportation is the movement of unnecessary material or equipment.
7. Overprocessing is a processing activity that does not add value to the product.
The seven types of construction waste above, need to be identified in detail and eliminated / reduced, or in other words, it is necessary to carry out an assessment of the waste that occurs. As stated in [7] that efforts to identify and eliminate waste systematically and continuously in the entire production process will lead to increased efficiency, improved process productivity and strengthening the overall competitiveness of the company. This activity has been widely carried out by the manufacturing industry which is useful for improving product quality, cost efficiency, and increasing the ability to fulfill consumer orders on time. Unfortunately, this is rarely done in the construction industry, especially those that have the same type as the manufacturing industry, namely in terms of producing a large number of construction products and carried out at the same time, as in housing production projects.

Based on the above problems, this paper discusses the application of an assessment of the waste that occurs in the simple housing development process using the Waste Assessment Model (WAM) developed by [7], and adjusted to the construction process being carried out. It is hoped that with the implementation of this assessment, efforts to identify and eliminate / reduce waste will be more accurate and can serve as a guide for contractors and developers who will produce housing for the community.

2. Research Methods

This research was conducted in 4 low-cost housing projects (housing A, B, C and D) based on the following criteria:
1. Having a goal to build a subsidized affordable house.
2. The development process is carried out using a system per work item to build several housing units at once.
3. The same work sequence, starting from excavation to finishing work.
   The construction process carried out by construction workers can be seen in Figure 1.

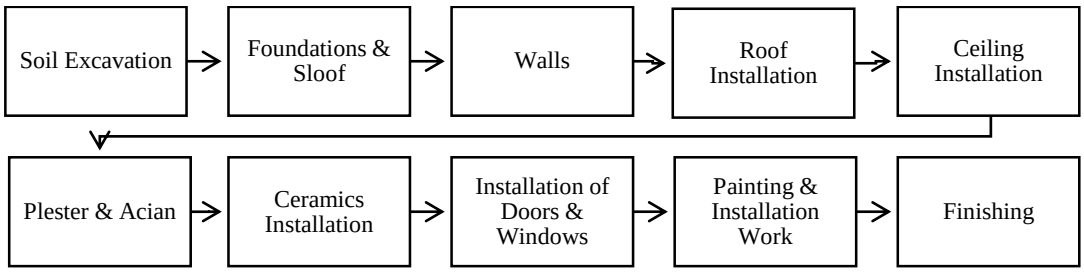

Figure 1. Sequence of House Construction Work in Low-cost Housing (Housing A, B, C, D)

Figure 1 shows a typical sequence of work performed by a contractor starting from excavation to finishing work. When a contractor gets a project of 10 housing units, then the process is carried out by workers doing excavation from the first house to the tenth house. Furthermore, workers do foundation and sloof work, from the first house to the last house, and so on until the final step (finishing).

4. There are no subcontracted works.

While the data collection method is carried out by distributing 2 types of Waste Assessment Model questionnaires, namely the Waste Relationship Matrix (WRM) and Waste Assessment Questionnaires (WAQ) according to reference [7] and modified with the conditions of a low cost housing construction project run by a contractor. This questionnaire was given to 22 respondents including 18 foremen and 4 field supervisors who were in housing A, B, C, D. This was because they were responsible and understood the construction process being carried out.

3. Results

This waste assessment is carried out for every job, from earth excavation to finishing work.

1) <u>For soil excavation work:</u>

A. Waste Relationship Matrix (WRM)

The function of Waste Relationship Matrix (WRM) is to measure the strength of each relationship between wastes directly, complete with its scale and presented in the form of a matrix.

To calculate the strength of the waste relationship, a measurement with questionnaire which has 31 relationship types i influences the type of waste j (i_j) [22] is developed. Each relationship was then given six questions with a scoring guide such as Table 1.

Table 1. List of questions for WRM analysis

No	Question	Answers	Score
1	Does i produce j	a. Always	4
		b. Sometimes	2
		c. Seldom	0
2	What is the relation between i and j	a. If i increases j increases	2
		b. If i increases j static	1
		c. Not depend on the condition	0
3	Impact on j because i	a. Can be seen immediately and clearly	4
		b. Need time to be seen	2
		c. Rarely seen	0

Table 1. List of questions for WRM analysis (Continuation)

No	Question	Answers	Score
4	Eliminating the impact i on j can be achieved by …..	a. Engineering Method	2
		b. Direct and simple	1
		c. Instructional solution	0
5	I's impact on j mainly affects…	a. Product quality	1
		b. Resource productivity	1
		c. Lead time	1
		d. Quality and productivity	2
		e. Quality and lead time	2
		f. Productivity and lead time	2
		g. Quality, productivity and lead time	4
6	How much impact i on j will increase the lead time	a. Very high	4
		b. Medium	2
		c. Low	0

Source: Rawabdeh (2005)

The score is then converted into a weighting symbol, the result of the weighting conversion will then be used to manufacture the Waste Relationship Matrix (WRM) (Figure 2).

For the excavation work, the WRM is as follows:

From/To	O	I	D	M	T	P	W
O	A	O	O	X	O	I	I
I	U	A	O	I	E	U	O
D	U	U	A	I	O	E	U
M	U	U	O	A	O	U	X
T	U	U	U	X	A	X	X
P	X	X	X	O	X	A	X
W	O	X	U	I	E	U	A

= Absolutely Necessary, E= Especially Important, I=Important, O=Ordinary Closeness, U= Unimportant, X=No Relation (Rawabdeh, 2005).

Figure 2. The WRM Excavation work

To put it simply, the matrix is then converted to numeric form with references A = 10, E = 8, I = 6, O = 4, U = 2, and X = 0, which is then poured into the Waste Matrix Value as Table 2.

Table 2. *Waste Matrix Value* of Excavation Work

From/To	O	I	D	M	T	P	W	Total	%
O	10	0	0	0	0	0	0	10	6,49
I	0	10	4	6	8	2	4	34	22,08
D	0	2	10	6	4	8	2	32	20,78
M	0	2	4	10	4	2	0	22	14,29
T	0	2	2	0	10	0	0	14	9,09
P	0	0	0	4	0	10	0	14	9,09
W	0	0	2	6	8	2	10	28	18,18
Total	10	16	22	32	34	24	16	154	100
%	6,49	10,39	14,29	20,78	22,08	15,58	10,39	100	

B. Waste Assessment Questionnaire (WAQ)

The waste value obtained from WRM is then used for initial assessment of WAQ based on the type of question. This assessment questionnaire consists of 68 different questions, with answer choices Yes = 1, Medium = 0.5, and No = 0, such as Table 3.

Table 3. *Waste Assessment Questionnaire* WAQ (Modification based on Rawabdeh, 2005)

No	Questions	Type of Question	Average
1	Does the foreman often transfer construction workers for all work so that one type of work can be done by all workers?	To Motion	0,46
2	Does the foreman set the standard for the amount of time and quality of targeted home products in production?	From Motion	0,17
3	Is supervision for night shift work (overtime) sufficient?	From Defects	0,08
4	Are there positive steps to improve morale?	From Motion	0,25
5	Is there a training program for construction workers?	From Motion	0,00
6	Does the worker have a sense of responsibility for his work?	From Defects	0,38
7	Has work safety protection been utilized at the project site?	From Process	0,13
8	Is the lead time available to arrange the home construction schedule?	To Waiting	0,38
9	Has the schedule been checked for the availability of construction material before carrying out the housing construction process?	From Waiting	0,25
10	Is material received in a single load / shipment?	From Transportation	0,33
11	Does the construction plan provide enough information to construction workers including material storage activities?	From Inventory	0,29
12	Are construction workers reminded before planned changes to the material inventory?	From Defects	0,29
13	Are there excessive materials waiting to be reused?	From Inventory	0,29
14	Are there any unnecessary materials around the pile of material?	From Waiting	0,42
15	Are construction workers standing around the project site waiting for material?	To Defects	0,17
16	Are construction materials moved more often than needed?	To Defect Material	0,29
17	Are construction materials often damaged when moved from a storage warehouse?	From Defect Material	0,29
18	Is the Work in Process (WIP) area confused with scattered material that will be used for future work?	From transportation Material	0,50
19	Should the material being unloaded mechanically have to be handled manually?	To Motion Material	0,13
20	Are transportation equipment available to transport material from the storage warehouse	From Waiting Material	0,42
21	Are the same construction materials stored at one location to minimize search time when handling supplies?	From Motion Material	0,54

Table 4. *Waste Assessment Questionnaire* WAQ (Modification based on Rawabdeh, 2005) (Continuation)

No	Questions	Type of Question	Average
22	Are transportation equipment available to transport material from adequate storage?	From Transportation Material	0,42
23	Is the conformity of construction material specifications checked when received from the supplier?	From Defect Material	0,38
24	Can construction materials be easily identified in storage?	From Motion Material	0,58
25	Will construction of construction materials still be in the Work In Process (WIP) process for future work?	From Inventory Material	0,54
26	Is order and storage of construction materials made for supplies, even if they are not needed immediately??	From Inventory Material	0,46
27	Is the Work in Process (WIP) flow relaxed?	To Waiting Material	0,25
28	Are repairs / rework done for work results that are not appropriate?	From Defect Material	0,63
29	Do construction materials arrive on time when needed?	From Waiting Material	0,21
30	Are there piles of construction material in the storage warehouse?	From Overproduction Material	0,58
31	Are construction materials stored properly?	To Motion Material	0,38
32	Has the testing of standard specifications of consumer home products been carried out periodically?	From Process Machine	0,13
33	Is the workload for each work equipment clearly predictable?	To Waiting Machine	0,25
34	Are the equipment inspected based on performance suitability and specifications?	From Process Machine	0,17
35	Are material handling equipment sufficient to accommodate the heaviest loads?	From Transportation Machine	0,42
36	Is the equipment for transporting material sufficient?	To Motion Machine	0,42
37	Is there a policy of producing excess consumer homes so that the equipment used is more effective?	From Overproduction Machine	0,29
38	Does the equipment used in building houses often suffer damage?	From Waiting Machine	0,13
39	Is the required equipment available and sufficient for each process?	From Waiting Machine	0,46
40	Can the equipment for transporting material cause damage?	To Defect Machine	0,29
41	Does the home construction process contain work items that last longer and cause delays in the process flow?	From Waiting Machine	0,79

Table 4. *Waste Assessment Questionnaire* WAQ (Modification based on Rawabdeh, 2005) (Continuation)

No	Questions	Type of Question	Average
42	Are there any tools that are not used / damaged but are still available at the workplace?	To Motion Machine	0,13
43	Are considerations being taken to minimize the frequency of work items adjusted to the scheduling and design?	From Process Machine	0,21
44	Are stock areas available to avoid the bottleneck of the consumer home construction process?	To Transportation Method	0,25
45	Is there a numbering system for retrieving material that makes it easy to find and store?	From Motion Method	0,00
46	Are there shelves inside the material warehouse?	From Waiting Method	0,08
47	Is the material storage warehouse divided into two areas, the active area for the most frequent orders and the reserve stock for other orders?	To Motion Method	0,54
48	Is quality control always applied in the process of building consumer homes?	From Defect Method	0,33
49	Is the production schedule communicated between departments (contractors and foremen), so that the schedule is widely understood?	To Defect Method	0,46
50	Has the production standard for housing construction been carried out?	From Motion Method	0,33
51	Is there an application of quality control in the process of building consumer homes?	From Defect Method	0,38
52	Does each work item have a standard time calculated according to engineering?	From Motion Method	0,08
53	If a delay is determined, is the delay communicated to all parties involved such as contractors, foremen, field supervisors and construction workers?	To Waiting Method	0,33
54	Is there a scheduling of construction work to avoid repetition of the same job?	From Process Method	0,29
55	Is there a possibility to combine per work item (2 work items done simultaneously)?	From Process Method	0,67
56	Are there procedures for work inspection / supervision?	To Defect Method	0,42
57	Is the inventory file used to calculate material purchases and schedule housing construction?	From Inventory Method	0,08
58	Is the project location always cleaned and tidied up well?	To Transportation Method	0,54
59	Are warehouses marked with certain parts?	To Motion Method	0,13
60	Is the project site area sufficient for free movement of equipment?	To Transportation Method	0,38

Table 4. *Waste Assessment Questionnaire* WAQ (Modification based on Rawabdeh, 2005) (Continuation)

No	Questions	Type of Question	Average
61	Are warehouses used to store material that should not be stored?	To Motion Method	0,33
62	Is there a fixed schedule for cleaning up project sites?	To Motion Method	0,67
63	Is the production flow done in one direction (consumer's house is built on demand)?	From Motion Method	0,42
64	Is there a group that deals with design, construction components, drafting, and other forms of standardization?	From Motion Method	0,46
65	Do work standards have clear and specific goals?	From Motion Method	0,42
66	Can work imbalances be predicted?	From Overproduction Method	0,25
67	Are existing work procedures able to eliminate unnecessary or excessive work?	From Process Method	0,21
68	Are the results of quality control, product testing, and evaluation carried out with engineering?	From Defect Method	0,08

The results of the questionnaire will be processed to assess and rank the existing waste based on the seven following steps.

1. Give weight to each question in the questionnaire based on the Waste Relativity Matrix (Table 5).

Table 5. Initial Weight of Question based on WRM

No	Questions	Type of Questions	Initial Weight For Each Type Of Waste						
			O	I	D	M	T	P	W
1	Man	To Motion	0	6	6	10	0	4	6
2		From Motion	0	2	4	10	4	2	0
3		From Defects	0	2	10	6	4	8	2
4		From Motion	0	2	4	10	4	2	0
5		From Motion	0	2	4	10	4	2	0
6		From Defects	0	2	10	6	4	8	2
…									
63	Method	From Motion	0	2	4	10	4	2	0
64		From Motion	0	2	4	10	4	2	0
65		From Motion	0	2	4	10	4	2	0
66		From Overproduction	10	0	0	0	0	0	0
67		From Process	0	0	0	4	0	10	0
68		From Defects	0	2	10	6	4	8	2
Total Score			30	220	288	388	266	220	256

2. Divide each weight in a row by the number of grouped questions (Ni).
3. Calculate the total score (sj) and frequency (fj) regardless of the value of 0 (Table 6)

Table 6. The Weight of Question divided by Ni

No	Aspects of Questions	Type of Questions	Ni	Initial Weight For Each Type Of Waste (Wjk)						
				Wo.k	Wi.k	Wd.k	Wm.k	Wt.k	Wp.k	Ww.k
1	Man	To Motion	9	0,00	0,67	0,67	1,11	0,00	0,44	0,67
2		From Motion	11	0,00	0,18	0,36	0,91	0,36	0,18	0,00
3		From Defects	8	0,00	0,25	1,25	0,75	0,50	1,00	0,25
4		From Motion	11	0,00	0,18	0,36	0,91	0,36	0,18	0,00
5		From Motion	11	0,00	0,18	0,36	0,91	0,36	0,18	0,00
6		From Defects	8	0,00	0,25	1,25	0,75	0,50	1,00	0,25
…										
63	Method	From Motion	11	0,00	0,18	0,36	0,91	0,36	0,18	0,00
64		From Motion	11	0,00	0,18	0,36	0,91	0,36	0,18	0,00
65		From Motion	11	0,00	0,18	0,36	0,91	0,36	0,18	0,00
66		From Overproduction	3	3,33	0,00	0,00	0,00	0,00	0,00	0,00
67		From Process	7	0,00	0,00	0,00	0,57	0,00	1,43	0,00
68		From Defects	8	0,00	0,25	1,25	0,75	0,50	1,00	0,25
Total Score (sj)				10,00	38,00	44,00	50,00	46,00	28,00	42,00
Total Frekuensi (fj)				65,00	50	59	56	44	49	44

4. Enter the reults of the questionnaire scores in Table 6 into each weight value in table 7 by multiplying them.
5. Calculate the total score (Sj) and frequency (Fj) regardless of the value of 0.

Table 7. Multiplication of Weight with Questionnaire Results Assessment

No	Aspects of Questions	Type of Questions	Average Answers of WAQ	Initial Weight For Each Type Of Waste (Wjk)						
				Wo.k	Wi.k	Wd.k	Wm.k	Wt.k	Wp.k	Ww.k
1	Man	To Motion	0,46	0,00	0,31	0,31	0,51	0,00	0,20	0,31
2		From Motion	0,17	0,00	0,03	0,06	0,15	0,06	0,03	0,00
3		From Defects	0,08	0,00	0,02	0,10	0,06	0,04	0,08	0,02
4		From Motion	0,25	0,00	0,05	0,09	0,23	0,09	0,05	0,00
5		From Motion	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
6		From Defects	0,38	0,00	0,09	0,47	0,28	0,19	0,38	0,09
…										
63	Method	From Motion	0,42	0,00	0,08	0,15	0,38	0,15	0,08	0,00
64		From Motion	0,46	0,00	0,08	0,17	0,42	0,17	0,08	0,00
65		From Motion	0,42	0,00	0,08	0,15	0,38	0,15	0,08	0,00
66		From Overproduction	0,25	0,83	0,00	0,00	0,00	0,00	0,00	0,00
67		From Process	0,21	0,00	0,00	0,00	0,12	0,00	0,30	0,00
68		From Defects	0,08	0,00	0,02	0,10	0,06	0,04	0,08	0,02
Total Score (Sj)				3,75	13,44	15,08	16,34	16,49	8,38	14,17
Total Frekuency (Fj)				65	48	56	55	42	47	43

6. Calculate the initial indicator for each waste (Yj). This indicator is only a number, which still does not represent that each type of waste is influenced by other types of waste.
   - Yj = sj/Sj x fj/Fj for each type of waste

7. Calculate the final value of waste factor (final yj) by multiplying the initial indicator with the probability factor of influence between types of waste (Pj) based on the total "From" and "To". Pj is obtained by multiplying the percentage "From" and "To" in the Waste Matrix Value for each type of waste.
   - Yj final = Yj x Pj = (sj/Sj x fj/Fj) x Pj for each type of waste

The final results of Yj for Excavation work as Table 8.

Table 8. Calculation results of *Waste Assessment Model* (WAM) Excavation Works

	O	I	D	M	T	P	W
Score Yj	2,67	2,95	3,07	3,11	2,92	3,48	3,03
Pj Factor	0,00	0,02	0,03	0,03	0,02	0,01	0,02
Yj Final	0,01	0,07	0,09	0,09	0,06	0,05	0,06
Result (%)	2,63%	15,80%	21,33%	21,62%	13,71%	11,53%	13,39%

Next, the same process (WRM and WAQ calculations) is also carried out on all work (foundation work to finishing work), the results of which are recapitulated as shown in Table 9.

Table 9. Recapitulation of *Waste Assessment Model* (WAM) for Low-cost Housing Development Process

No	Projects	O	I	D	M	T	P	W	Total
1	Excavation	2,63%	15,8%	21,33%	21,62 %	13,71 %	11,53 %	13,39%	100%
2	Foundation & Sloof	20,88 %	12,25 %	23,46%	13,74 %	8,44%	8,59%	12,64%	100%
3	Wall	17,27 %	9,93%	25,13%	12,28 %	9,94%	9,22%	16,22%	100%
4	Roof	1,81%	12,62 %	23,34%	25,29 %	5,68%	15,31 %	15,96%	100%
5	Ceiling	15,93 %	13,05 %	20,59%	16,64 %	6,02%	10,83 %	16,93%	100%
6	Plaster & Acian	15,07 %	11,51 %	18,92%	18,21 %	18%	11,32 %	16,96%	100%
7	Ceramics	15,16 %	11,88 %	18,49%	17,86 %	8,24%	11,25 %	17,12%	100%
8	Doors & Windows	13,35 %	11,63 %	19,32%	18,47 %	8,13%	11,45 %	17,64%	100%
9	Paint & Installation	13,35 %	11,63 %	19,32%	18,47 %	8,13%	11,45 %	17,64%	100%
10	Cleaning	15,16 %	11,88 %	18,49%	17,86 %	8,24%	11,25 %	17,12%	100%
	Average	13%	12%	21%	18%	9%	11%	16%	
	Ranking	4	5	1	2	7	6	3	

Graphically, the waste ranking of the low-cost housing development process based on WAM in Table 9 can be seen in Figure 3.

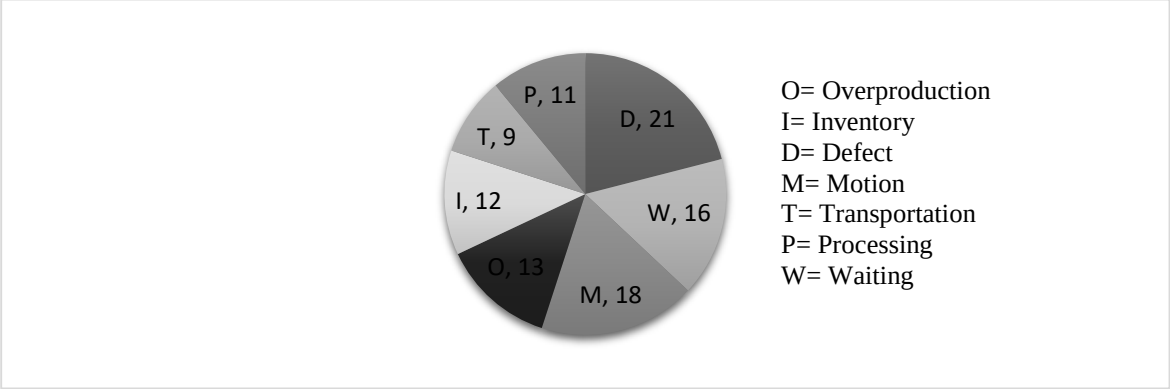

Figure 3. Pie Chart Ranking Waste Process of Low-cost Housing Development

In Figure 3, it can be seen that for all jobs, the highest to the lowest rankings are:

1. Defect (21%).
   Defect are the result of unexpected construction processes, such as cracked walls, leaked roof, peeled paint, and so on. This happens because the work processes and materials used do not meet specifications and requirements. As a result, workers must repair and rework, so that it can have an impact on the length of time work in process (WIP) for each step.
2. Motion (18%)
   Motion is a slow movement of workers because of the quality of workers who are less skilled and experienced. As a result, the work in progress is longer.
3. Waiting (16%)
   Waiting is a waiting activity, both waiting for material from the storage warehouse to be used in the housing unit, and waiting for material from the supplier, while waiting for work to start, usually the result of delays in completing the previous process. All of these wastes lead to longer cycle times, resulting in the completion of work not in accordance with the contract.
4. Overproduction (13%)
   Overproduction is when products exceed the demand, such as mortar and sand that is too much, cutting too any iron for sloof or columns / poles, and others. Inventory is a buildup of goods in a storage warehouse because material goods are not neatly arranged. This can cause material damage or decrease in material quality due to inadequate storage systems and storage conditions. As a result, if poor quality materials are still being used, it will have an impact on the building which will lead to repairs and rework. Inventory (12%)
5. Inventory is the accumulation of goods in storage because material goods are not neatly arranged. This can cause material deterioration or deterioration of material quality due to inadequate storage systems and storage conditions. As a result, if materials of poor quality are still used, it will have an impact on building defects so repairs and rework must be carried out. Inventory occurs because no logistic operator is responsible for the available materials. Such as arranging the entry and exit of materials to the housing unit to be built, checking the quantity and condition of materials originating from the supplier, arranging materials in the storage warehouse, checking the availability of materials in the storage warehouse, and providing adequate facilities (carts). In addition, the logistics officer must also intensively report the availability of materials to the contractor, so that they can place orders again when the material runs out and the work process will be carried out immediately.
6. Processing (11%)
   Processing is a work activity that does not meet the requirements, such as making a mixture of cement and sand with an incorrect composition, ceramic tiles that are not soaked before being installed, insufficient digging depth, and so on. As a result, it has an impact on building defects, so it must be repaired and reworked again.

7. Transportation (9%)
   Transportation is the activity of transporting materials from an inadequate storage warehouse. This occurs due to the limited number of workers and carts to transport materials, as well as inadequate road conditions (muddy roads) around the project site.

From these data, it can be determined the priority of waste which must be taken immediately by reducing action in the process of simple housing construction is waste ranked first (defect), followed by waste ranked second (motion), and waste ranked third (waiting). Therefore, these three wastes should be a major concern for contractors to always conduct evaluations with the foreman and field supervisors and find the right solution to overcome them.

According to [8], Defect can make up 4% of the contract value of a newly built or renovated residence project. And [9] consequently on the cost of defects that will reduce the profits of builders and real estate management organizations and can damage the company's reputation and reduce customer satisfaction. Therefore, [10] building defects have a significant effect on industry and society, and are considered a critical problem that must be addressed**.**

Related to waste motion, according to [11], motion is unnecessary physical movement performed by workers so that it diverts them from the actual processing work. This can be caused by an inadequate factory floor / project site, which affects body movement or ergonomics and can slow down work. In the simple housing development process, this is more due to the fact that workers are late in receiving work directions from the foreman, or there is no supervision from the foreman or field supervisor, so they do work that does not bring value (Non-Value Added Activities / NVA). Such as chatting, playing cellphones and others, which in the end the work that must be done becomes neglected.

Meanwhile, Waiting/ Delay waste occurs before the work is carried out, and when the work is in progress due to: 1) The number of workers is not yet available, 2) The material is not yet available. 3) The foreman has not received an order to start work from the contractor. 4). The contractor does not have sufficient capital to be used to purchase materials and other operating funds. If waiting / delay occurs for the first job only (earth excavation and septic tank), then it is certain that the next work will be delayed from the set schedule. This is in line with the opinion [12] which states that delay will have a negative impact on project activities and results. Because the delay will extend the duration and increase the cost of the project, which will have an impact on increasing resource consumption and require extra time to complete. In a housing project, a developer can be the owner of the project as well as a contractor, where the developer must meet certain requirements which are clearly stated in the contract document.

4. Conclusion

Based on the results of the waste assessment in the simple housing construction process using the Waste Assessment Model (WAM), the top to bottom ranking of waste is defects (21%), motion (18%), waiting (16%), overproduction (13%). , inventory (12%), processing (11%) and transportation (9%). From this data, there are three main wastes (highest ranking) that must be considered by contractors and must be eliminated / reduced immediately, namely waste defects, motion and waiting.

Apart from the three main wastes above, the other four wastes (overproduction, inventory, processing and transportation) should also not be ignored, considering that almost all of the work contains the four wastes in their implementation and has the potential to cause project delays.

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