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Implementation of Lean Construction to Reduce Waste with the Value Stream Analysis Tools (VALSAT) Method in the Project Casting Process

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Abstract

This study aims to identify waste that occurs in the casting process of the project carried out by CV. Wishitama using value stream analysis tools (VALSAT) and provide suggestions for improvements with fishbone diagrams for the casting process of the project carried out by CV. Wishitama. This study uses a qualitative approach and case study with value stream analysis tools (VALSAT) and fishbone diagram analysis. The results of this study are that there are four types of waste that are prioritized for elimination, namely, overprocessing, defective products, queues, and motion. This study will provide new contributions to knowledge in the field of lean construction, with a focus on the construction industry. The results of this study will complement existing knowledge and provide new insights into how the application of lean construction can eliminate waste in the construction industry. Companies can eliminate and be effective in waiting for heavy equipment (readymix and concrete pumps) and vibrating equipment during casting. In addition, companies can increase direct supervision, conduct additional training, conduct evaluations, implement a reward or punishment system according to employee performance, plan efficient schedules, assign employees according to needs, and conduct outreach on current employee performance as a form of effort to improve human resources.

Keywords: Fishbone Diagram, Lean Construction, dan Value Stream Mapping.

JEL Classification: C44

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1. Introduction

The construction industry is one of the main sectors that has a significant impact on human life. The construction industry is recognized as one of the main pillars in the economy of many countries around the world, as it has a significant impact on national income (Shaqour, 2022). The role and contribution of the construction industry affect the global and national economy in increasing public satisfaction and trust (Yücenur & Şenol, 2021). However, this sector is also often considered the main cause of waste problems that have a negative impact on the economy and the environment (Shaqour, 2022).

In the context of the construction industry, lean principles are adopted to reduce waste and increase efficiency in the construction process (Patel et al., 2023). The occurrence of waste can have a negative impact on the performance of construction companies (Patel et al., 2023). Companies must eliminate waste, which is the main factor that damages efficiency in the construction industry caused by inappropriate or improperly planned processes (Yücenur & Şenol, 2021). Since its first introduction in the early 1990s, the concept of lean construction has succeeded in attracting the interest of many companies and practitioners around the world (Albalkhy & Sweis, 2021). The application of the lean concept has significantly and continuously had a positive impact on increasing productivity, quality, more efficient waste management, and various other performance indicators in the construction industry. Therefore, the construction industry has become a pioneer in adopting lean thinking and techniques (Ahmed et al., 2021).

CV. Wishitama is a private construction company in Indonesia that was established in 1996. CV. Wishitama has worked on building projects in various cities in Indonesia with its head office in Surabaya City covering the entire East Java region. CV. Wishitama has been given trust by both the government and the private sector to handle various building and civil engineering projects (office buildings, factories, warehouses, health centers, schools, markets, sports facilities, dams, and so on). Based on LKPP Regulation Number 11 of 2021 concerning Guidelines for Government Procurement of Goods/Services Planning, packaging of construction service procurement, provisions for packaging Construction Work are divided into three qualifications, namely small businesses, medium businesses, and large businesses. This qualification division is based on the ceiling value with the provision that for small businesses the budget ceiling value is up to Rp15,000,000,000.00 (fifteen billion rupiah), for medium businesses the budget ceiling value is above Rp15,000,000,000.00 (fifteen billion rupiah) up to Rp50,000,000,000.00 (fifty billion rupiah), and for large businesses the budget ceiling value is above Rp100,000,000,000.00 (one hundred billion rupiah) allocated only for Construction Work Providers. CV. Wishitama is a small construction company because it only works on projects with a ceiling value of up to Rp15,000,000,000.00 (fifteen billion rupiah).

Table 1 List of CV. Wishitama Project Delays Due to Casting Process 2022-2023

Project	Project Value	Delays
Rehabilitation of Blimbing Kesamben Health Center Building in 2023	Rp. 2.496.163.556	1 Week
Construction and Rehabilitation of Toilet Building and Classrooms of SMPN 9 in 2023	Rp. 1.346.376.919	3 Weeks
Bendung Bareng Rehabilitation in 2022	Rp. 4.645.485.000	1 Week
Rehabilitation of Mojokerto City Square Park in 2022 (Monument and Pond)	Rp. 2.780.107.915	1 Week
Construction Work for the Construction of New Classroom Buildings at MAN 1 Batu City in 2022	Rp. 2.442.808.774	2 Weeks

In every project carried out by CV. Wishitama, there is always a casting process in collaboration with PT. SPU Mix or PT. Merak Jaya Beton. Based on preliminary interviews, problems were found in this process related to resource inefficiency in the process. This resource inefficiency requires

improvements and the time required to carry out casting is longer than planned. As in table 1.1, the delay in the process increases the duration of the project for one to three weeks with different reasons for waste. This is caused by several wastes that occur. Waste is an activity that does not add value in the eyes of customers. If this is not fixed by the company and occurs again in future projects, it is feared that it will reduce the company's performance both in terms of quality and timeliness of the projects being worked on. This study was conducted to identify waste that occurs in the project casting process. So it is hoped that by identifying the waste that occurs in this process, it can be an evaluation and provide input for projects that are always worked on by CV. Wishitama and can improve the quality of the company's performance. The application of lean construction is expected to provide solutions for companies on how to reduce waste and activities that are considered to have no added value that occur. It is expected that the company can meet demand faster and more efficiently, while maintaining quality without waste. The company will maintain the flow of products and services so as to provide what customers want at the right cost, quantity, and time.

This study will provide identification of waste that occurs and suggestions for improvements in the casting process of the project carried out by CV. Wishitama so far as evaluation material and input for the next project so that the same problem does not occur. There are seven types of waste introduced by Taiichi Ohno, namely overproduction, queues, transportation, inventory, motion, overprocessing, and defective products. The seven types of waste are considered as activities that do not have added value in the eyes of customers. To realize the implementation of lean construction to eliminate waste, researchers use the value stream analysis tools (VALSAT) analysis method. Value stream analysis tools (VALSAT) is a method that can implement lean principles appropriately by identifying waste that can be eliminated with various considerations. In addition, this researcher uses a fishbone diagram as a tool to determine the root cause of the waste that occurs. The results of the study with this method will be used as a reference for suggestions for improvements to the waste that occurs so that it does not happen again in projects that will be worked on in the future. The proposed improvements are expected to help companies meet demand more efficiently and maintain quality with less waste. With less waste, of course, the company will save time and money.

2. Literature Review and Hypothesis Development

Quality can be interpreted in several ways depending on the perspective, focus, and context in question. Quality is defined as characteristics and services to meet customer needs, how services match customer needs, and as a reference in seeing the difference between customer perceptions and expectations (Volsuuri et al., 2023). Quality in the context of the manufacturing industry, processes, and services can be simply interpreted as an effort to meet customer needs, achieving results with usefulness, and results that are in accordance with provisions (Rumane, 2017). The main goal in the service sector is customer satisfaction. Quality will maintain the services provided by a person, organization, or company to other parties in providing the services offered (Volsuuri et al., 2023).

Quality in the context of the construction industry is slightly different from the definition of quality for the context of the manufacturing, process, and service industries. This difference is due to the activities in the construction industry running specifically. Each construction project has its own differences and uniqueness with other construction projects (Rumane, 2017). Not only paying attention to the quality of raw materials, equipment, and results used to build a project, quality in the context of a construction project pays attention to the overall management approach to completing

the project. Expectations regarding the quality of a project are also not only considered by the project's clients, but the community also has expectations because the project can be a public space. The last quality that is considered is the cost and time required to complete a project.

Lean is a method for designing a production system that aims to reduce waste in the use of materials, time, and effort with the aim of producing maximum value (Koskela et al., 2002). Lean production was

introduced as an effort that refers to continuous efforts to achieve excellence in production by reducing all types of waste (Koskela et al., 2002). There are seven types of waste, namely inventory, waiting, defects, overproduction, motion, transportation, and over-processing (Heizer et al., 2017). Each type of waste is considered an unproductive activity because it uses resources, including time, without providing significant benefits (Saetta & Caldarelli, 2023). Lean has several shortcomings in several areas that make researchers increasingly have the opportunity to define a better lean philosophy (Abu et al., 2019). Therefore, lean can be an approach with the main goal of gaining benefits from lean tools by eliminating waste, developing knowledge, and work culture (Abu et al., 2019). Lean operations are driven by customer-initiated workflows. Lean operations is a continuous problem-solving approach that focuses on outcomes and inventory reduction (Heizer et al., 2017). Regardless of the approach and label, operations managers address three fundamental issues for operations improvement: reducing waste, eliminating variability, and improving the bottom line. The concepts of transformation, flow, and value concepts can be used to categorize production theories and related tools. Lean production seeks to combine these three production concepts in an integrative manner (Koskela et al., 2002).

Casting is an important part of any building construction project. Casting is carried out before all project processes are carried out, namely for casting the concrete foundation of the building. In the research of Zahraee et al. (2020), the implementation of casting was carried out in two main stages: [1] pouring concrete on slabs and beams, and [2] pouring concrete on walls and columns. Concrete trucks are used to transport concrete to the construction site. The project casting process begins with pumping. After the concrete is prepared and tested, the concrete is poured using a concrete pump. This step requires an operator to carry out the pumping process. After that, the concrete in the concrete truck has been completely pumped, it is time for other resource crews to complete the remaining concrete operations which sequentially include spreading, vibrating, and final finishing.

Value stream mapping is a method in lean manufacturing that can be used to analyze, design, and manage the process flow of delivering products to customers, either materials or information needed. From the customer's perspective, value stream mapping positions the process as value-added or not. This aims to eliminate waste and activities that do not add value (Dinesh et al., 2022). Value stream mapping offers higher effectiveness by presenting information on the calculation of non-value-added steps, distance traveled, waiting time, and the amount of inventory in a process (Zahraee et al., 2020). In the context of the lean approach, all forms of waste that exist in the entire process flow that changes input into output must be eliminated to increase product value and customer satisfaction (Suryanti et al., 2020). Value stream mapping is one method in lean manufacturing that can be used to map conditions in a process flow in production or activities in a company. In addition, value stream mapping can identify various types of waste to be eliminated (Suryanti et al., 2020). Value stream mapping has been widely used in producing process flow diagrams for activities and other project information. Value stream mapping records in detail each step of the process and work flow which is then systematically mapped to analyze these processes to develop improvement plans (Ramani & KSD, 2021).

Hines & Rich (1997), explains how the relationship between the seven mapping tools and waste. The relationship describes the relationship of each waste to the tools to be used. Therefore, before making improvements in the process flow, it is necessary to determine which waste will be reduced before the mapping activity is carried out. Each of these tools is reviewed in turn before a discussion is held on how the tools can be selected for use. The simpler value stream analysis tool begins by identifying the specific process flow to be analyzed. Then, conduct preliminary interviews with managers to identify waste that occurs in the process flow that can be eliminated (Hines & Rich, 1997). Before choosing the tools to be used, the resource person is given a written description in the form of a questionnaire to assess which waste has the greatest impact on the company or industry. The results of the assessment are calculated with the relationship to the seven stream mapping tools. The results of this calculation will determine which tools will be used to find solutions for the waste to be

eliminated. After the assessment is carried out, the results of the assessment are compared with the tools in the seven stream mapping tools to determine which tools will be used to find solutions to minimize waste in the company or industry (Hines & Rich, 1997). The value that has been determined by the managers for each waste will then be multiplied by the score for each tool. The score for each tool is determined based on their relationship with the waste. Tools that have a high relationship are equivalent to nine points, medium is equivalent to three points, and low is equivalent to one point. Then, for each relationship, the total score is calculated by multiplying the waste value by the tool. After the calculation is done, you can identify and determine which tools will be used to eliminate waste.

Fishbone diagram or cause-and-effect diagram is a visual representation that illustrates the relationship between specific negative impacts and their possible causes (Dumas et al., 2018). In the context of process analysis, these negative impacts often include recurring problems or unsatisfactory process performance. Fishbone diagrams organize factors into categories and subcategories to help guide root cause identification (Dumas et al., 2018). The result of this process is a list of potential factors that must then be validated through data collection from relevant information systems or direct observation of the process. The goal is to verify whether the occurrence of the negative impact can be directly linked to the presence of the identified potential factors.

3. Data and Methodology

Research approaches can be divided into two, namely quantitative research and qualitative research. In this study, researchers use a qualitative approach as a method to formulate answers to the formulation of research problems from CV. Wishitama as the company being studied. A qualitative approach is an approach that uses data in the form of words which are then analyzed to obtain conclusions or valid results based on the amount of data that is ultimately used to obtain answers to the formulation of research problems (Sekaran & Bougie, 2016). Qualitative data can be in the form of interview notes, group discussion transcripts, answers to open-ended questions, video recording transcripts, experiences with a product on the Internet, news articles, and so on. Qualitative data can be obtained from various sources such as individuals, focus groups, company records, government publications, and the internet from both primary and secondary sources (Sekaran & Bougie, 2016). In this study, both primary and secondary data sources will be used in the form of interview notes, company profiles, company project history lists, and final company project reports.

This approach is used by considering the formulation of the problem and the purpose of the study, namely identifying waste that occurs in the casting process of the project carried out by CV. Wishitama using value stream analysis tools (VALSAT) and providing suggestions for improvement with a fishbone diagram for the casting process of the project carried out by CV. Wishitama. This approach is considered appropriate because it will provide direct data from the parties responsible for their fields as analysis material in this study. This approach will also provide detailed analysis results from researchers who have collected direct data and processed it regarding the field of building construction to achieve research objectives.

The research strategy used in this study is a case study strategy. Case studies are one strategy that can be used for research with a qualitative approach. This case study strategy focuses on collecting data related to a particular subject, event, or action in a business unit or organization (Sekaran & Bougie, 2016). The subjects in a case study can be individuals, groups, organizations, events, or situations related to the focus of this study. Case studies can provide both qualitative and quantitative data that can be used for analysis and interpretation. In addition, as in experimental research, hypotheses can also be formulated in case studies (Sekaran & Bougie, 2016). This strategy is considered suitable for this study because the company to be studied is a company that carries out projects in practice. It is hoped that with this research strategy, detailed results can be obtained related to the topic being studied according to the real conditions and situations that occur in the field. This is also in accordance

with the conditions of companies that are currently carrying out development projects directly in the field.

The discussion of this research has limitations in its analysis due to several things. The limitations of this research are as follows:

1. This study aims to identify waste, eliminate waste, and provide suggestions on how to use value stream analysis tools (VALSAT) in the casting process of the project carried out by CV. Wishitama as an evaluation in order to minimize waste.
2. This research will focus on analyzing using value stream analysis tools (VALSAT) and fishbone diagrams.
3. This study only takes data related to the project casting process through the results of interviews with four sources in the company who are considered to have the most influence on the project casting process and related company documents.

This study uses two types of data. The data used to support this study are primary data and secondary data as follows:

1. Primary data is data collected directly by researchers for specific research purposes, using methods such as interviews, observations, or questionnaires so that they are considered more accurate and relevant for research (Sekaran & Bougie, 2016). Primary data in this study includes information obtained directly from four sources either by interview, questionnaire, or documentation in the company's project. The reason for choosing these sources is because it requires sources who know and are responsible for all activities at CV. Wishitama. The four sources to be interviewed are the project manager, field implementer, surveyor, and head of general operations.
2. Secondary data refers to data collected by others for purposes other than the current research objective. Some sources of secondary data include statistical bulletins, government publications, published or unpublished information available within or outside the organization, company websites, and the Internet (Sekaran & Bougie, 2016). The secondary data used for this study include company documents, company project histories, and company final reports.

Data collection is carried out to support the need for information as a reference for analysis in this study. According to Sekaran & Bougie (2016), there are several ways to collect data. Of these methods, this study uses the following methods:

1. Interview is an interaction between two or more people that is guided and has the purpose of obtaining information as a source of research data (Sekaran & Bougie, 2016). In this study, the information in question is to find out the process flow and waste that occurs in the project casting process. Interviews are methods that are widely used in business research. This study will use a structured interview type. A structured interview is an interview that is conducted with prepared questions to obtain any data needed (Sekaran & Bougie, 2016). However, in a structured interview, researchers can provide follow-up questions that are still relevant to topics that are not listed in the question list to support respondents' answers (Sekaran & Bougie, 2016). Structured interviews are considered suitable because they will provide focused answers and it is certain that the answers are understood by researchers so that it is expected to facilitate the analysis process.
2. Questionnaires are a method of collecting data by preparing written questions to be given to respondents to write their answers (Sekaran & Bougie, 2016). Questionnaires are usually used to collect large amounts of quantitative data (Sekaran & Bougie, 2016). The questionnaire in this study aims to determine the value of each waste that occurs and to find out the time for each activity of the project casting process.

3. Documentation is a way of collecting data by processing data that has been documented in the form of company documents, company reports, or other forms of documentation. In this study, the company profile, company project work methods, and final company project reports will be used.

Triangulation has several types that researchers can use to validate their research. Some of these types include data triangulation, method triangulation, researcher triangulation, and theory triangulation (Sekaran & Bougie, 2016). This study will use data triangulation and method triangulation. Data triangulation is a study that collects information from several sources of informants and/or at different times as sources of research information (Sekaran & Bougie, 2016). In this study, researchers used four different sources, namely project managers, field implementers, surveyors, and heads of general operations to obtain reliability and validity of information regarding process flow and waste information that occurs in the project casting process. Method triangulation is a study that applies several data collection methods for the information needed in its research (Sekaran & Bougie, 2016). In this study, researchers used three different methods, namely interviews, questionnaires, and documentation to obtain reliability and validity of information regarding process flow and waste information that occurs in the project casting process.

4. Results and Discussion

This study will provide results in the form of a list of waste that occurs and which ones must be eliminated as soon as possible in the casting process of the CV. Wishitama project. Thus, this study requires some data from CV. Wishitama such as the flow of the project casting process to be described with value stream mapping and waste assessment by CV. Wishitama. After waste is identified based on the process flow that has been described with value stream mapping, the researcher will use a fishbone diagram as a tool to analyze the root of the problem and provide suggestions for improvement.

The casting process is illustrated with value stream mapping which can be seen in Figure 4.1 to make it easier to identify problems and determine solutions. After conducting interviews with sources, current state mapping is depicted in Figure 4.1 to make it easier to find out where the waste occurs.

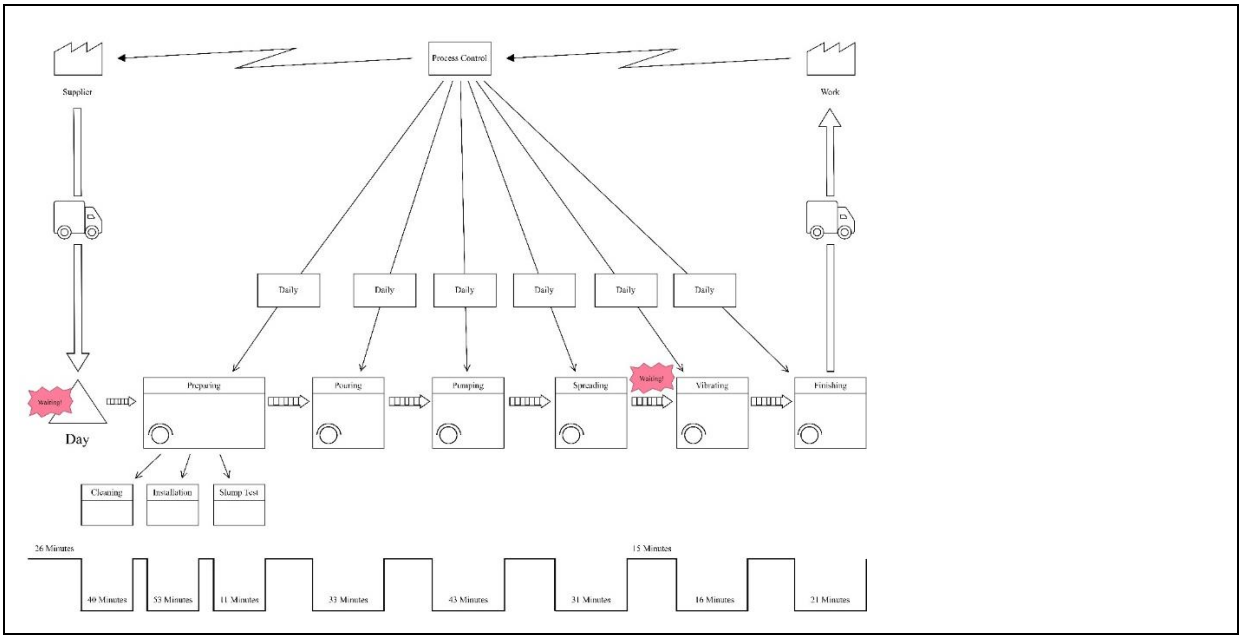

Figure 4.1 Current State Mapping of Casting Process

The casting process begins with ordering readymix from the supplier according to the quality required and when the casting process will be carried out. Based on the current state mapping of the results of interviews with informants in Figure 4.1, non-value-added activities were found in the form of waiting for preparation and vibrating activities. The next step is to determine the priority order of waste that often occurs and has a significant impact on the casting process based on the results of the waste interviews that occur. This is done in order to determine which waste must be eliminated immediately. Waste with the highest value will later be prioritized for elimination because it has the most significant impact on the casting process. The questionnaire was filled out by the four informants with the results of the waste assessment that occurred can be seen in table 4.1 below

Table 4.1 Waste Assessment Results in the Casting Process

Waste	Project Manager	Executor	Surveyor	Operational Manager	**Total**	**Average**	**Rank**
Overproduction	2	4	2	3	11	2,75	7
Queues	3	5	4	4	16	4	3
Transportation	3	4	4	4	15	3,75	5
Inventory	4	1	4	3	12	3	6
Motion	4	5	3	4	16	4	4
Overprocessing	4	4	5	5	18	4,5	1
Defective product	3	4	5	4	16	4	2

Based on the assessment results in table 4.1 above, it can be seen that the waste with the highest value is overprocessing, with an average value of 4.5. Then, defective products, queues, and motion

become waste in the next order with an average value of 4. After that, transportation becomes waste in the next order with an average value of 3.75. Furthermore, there is inventory which becomes waste in the next order with an average value of 3. The last rank is overproduction with an average value of 2.75. Therefore, the waste that will be prioritized is overprocessing, defective products, queues, and motion with the highest scores.

Table 4.2 Calculation Results of The Seven Value Stream Mapping Tools

Waste	Score	PAM	SCRM	PVF	QFM	DAM	DPA	PS
Overproduction	2,75	2,75	8,25		2,75	8,25	8,25	
Queues	4	36	36	4		12	12	
Transportation	3,75	33,75						3,75
Inventory	3	9	27	9		27	9	3
Motion	4	36	4					
Overprocessing	4,5	40,5		13,5	4,5		4,5	
Defective product	4	4			36			
TOTAL		162	75,25	26,5	43,25	47,25	33,75	6,75
RANKING		1	2	6	4	3	5	7

This study uses value stream analysis tools (VALSAT) to identify waste that occurs in the casting process of CV. Wishitama. After the waste assessment results are obtained, the next step is to connect them with the seven value stream mapping tools. This is done to determine the magnitude of waste that has an impact on the casting process with the types of tools available. To determine which tools are the most relevant and appropriate, calculations need to be made by multiplying the waste assessment results by the scores of each tool. The calculation results of the seven value stream mapping tools are explained in table 4.2 above.

Based on the calculation results of table 4.2, it was found that the highest value for tools in mapping tools is process activity mapping with a score of 162. Therefore, process activity mapping will be used to identify problem points and optimize them. This process activity mapping is expected to be a consideration for eliminating unnecessary activities based on waste assessment.

The use of process activity mapping aims to map activities in detail in several categories to make it easier to choose activities to be eliminated. Activities that have been identified are categorized into operation, transport, inspect, store, and delay. In addition, these activities will also be categorized whether they are value-adding (VA), non-value adding (NVA), necessary but non-value adding (NNVA). Based on the results of interviews and questionnaires, process activity mapping can be seen in table 4.3 below:

Table 4.3 List of CV. Wishitama Project Delays Due to Casting Process 2022-2023

NO	Activity	Number of people	Time (minutes)	Activity Category					Type
				O	T	I	S	D	
1	Waiting for readymix to arrive	0	26					*	NVA
2	Cleaning the location	4	40	*					NNVA
3	Heavy equipment installation	2	53				*		NNVA
4	Slump test	2	11			*			VA
5	Casting cast	3	33	*					VA
6	Cast pumping	3	43	*					VA
7	Spreading cast	3	31	*					VA
8	Waiting for vibrating tool preparation	0	15					*	NVA
9	Vibrating	3	16	*					VA
10	Next readymix preparation	0	21	*					NNVA
TOTAL			289	184	0	11	53	41	
Explanation			Time calculation for each readymix						

Based on table 4.3 above, a list of casting process activities for one readymix consists of 10 activities. Each activity is classified based on the categories of operation, transport, inspect, store, and delay. Activities included in the delay category will be attempted to be eliminated with consideration and improvement proposals. This category is considered not to add value and only adds to the time needed in one casting process. This activity is also classified into three types, namely value-adding (VA), non-value adding (NVA), necessary but non-value adding (NNVA). Activities included in non-value adding (NVA) will later be eliminated based on consideration and improvement proposals. The type of non-value adding (NVA) activity will be eliminated because it does not add value to the final casting result and only adds to the time needed. After elimination, the analysis results will be described in future state mapping.

After calculations and analysis are carried out to identify the waste that occurs, an analysis needs to be carried out to find out the root cause of each waste that occurs. Researchers use fishbone diagram analysis to find out the root cause through interviews with informants. After finding out the

root cause of each waste, researchers will conclude the proposed improvements for the casting process of CV. Wishitama in the future.

Overprocessing ranks first in the casting process of CV. Wishitama which has the highest impact and must be eliminated immediately. Based on interviews with Mr. Murtono and Mr. Anang, the root cause of waste overprocessing can be identified in Figure 4.2.

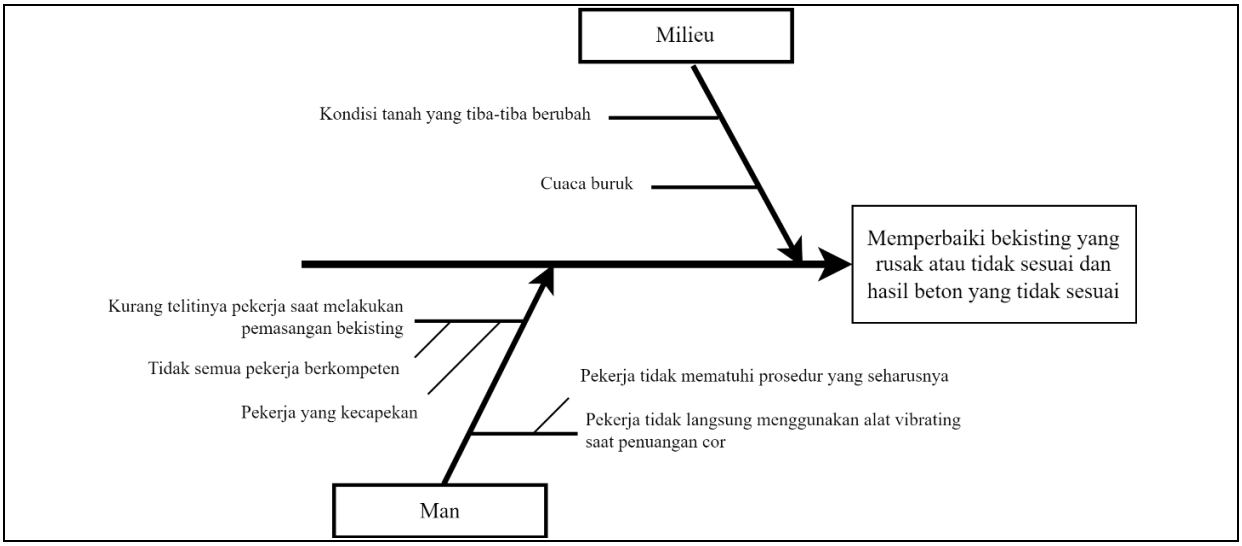

Figure 4.2 Fishbone Diagram Analysis for Waste Overprocessing

Queues refer to waiting or idle time due to waiting for an activity for any reason. In the context of project work in the casting process, an example of queues that occur is waiting for heavy equipment to arrive before being able to continue to the maintenance or curing process. Based on the interview with Mr. Murtono above, the root cause of waste queues can be identified as depicted in Figure 4.3.

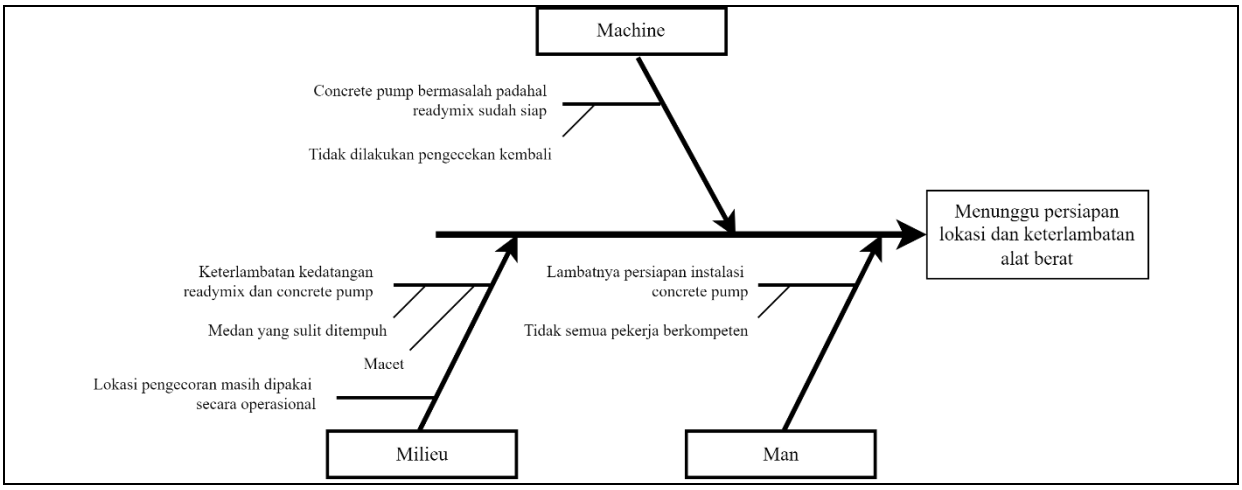

Figure 4.3Fishbone Diagram Analysis for Waste Queues

Defective product refers to the non-conformity of the final result with the existing standards so that it must be discarded or repaired which causes additional material, energy, and time. In the context of project work in the casting process, an example of a defective product that occurs is a leak in the formwork during casting or cracking of dried concrete so that repairs need to be made. Based

on the interviews with Mr. Murtono, Mas Ode, and Mr. Anang above, it can be seen that the waste defective product is depicted in Figure 4.4.

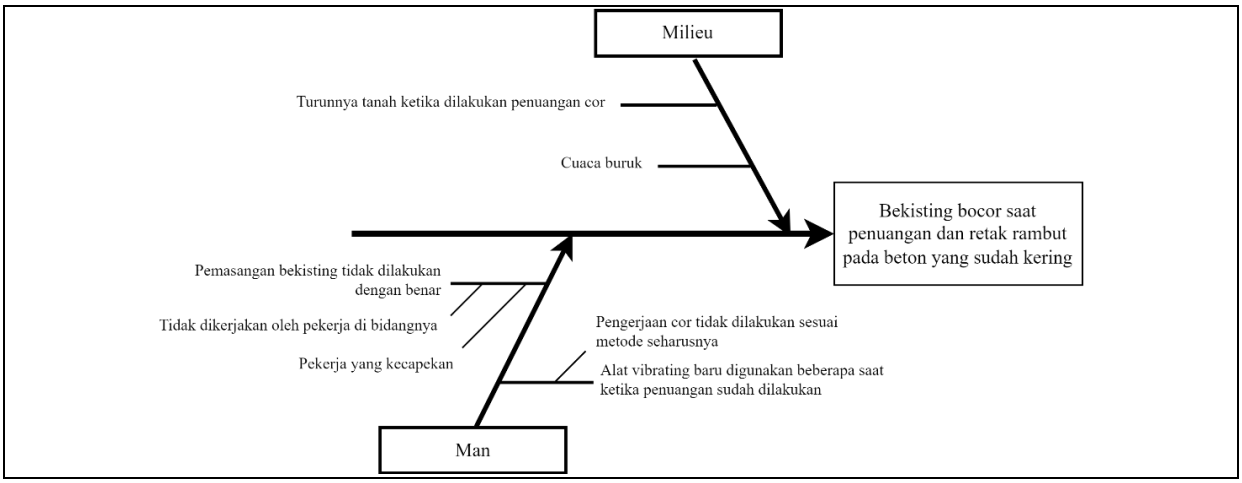

Figure 4.4 Fishbone Diagram Analysis for Waste Defective Products

Motion refers to movement that does not add value and can increase the use of space, material, or time in a process. In the context of project work in the casting process, an example of Motion that occurs is deploying too many workers in the field so that it is difficult for other workers to carry out activities. Based on the interview with Mr. Murtono above, it can be seen that waste motion is depicted in Figure 4.5 below.

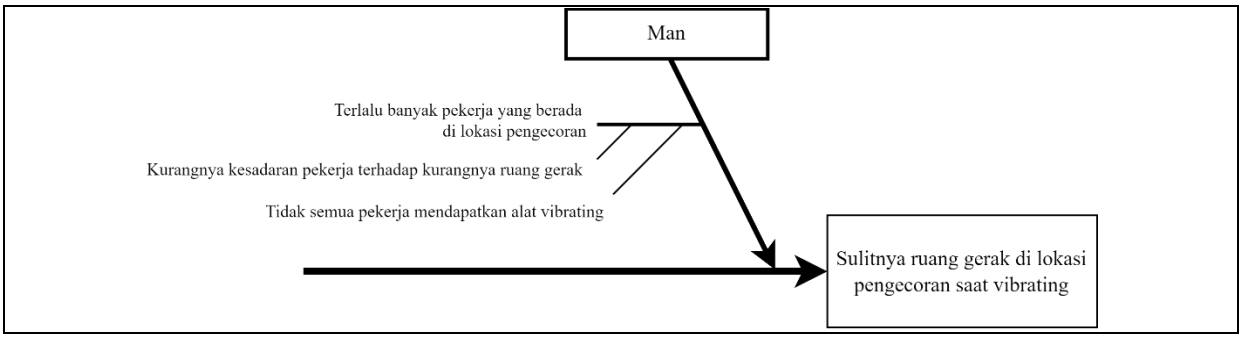

Figure 4.2
Fishbone Diagram Analysis for Waste Motion

Based on the results of the analysis using the fishbone diagram, this study will provide suggestions for improvements to the casting process of CV. Wishitama. This list of proposed improvements can later be used as considerations, input, and evaluations for the casting process of CV. Wishitama in order to reduce the possibility of the same waste and increase the effectiveness of the casting process. The following is table 4.4 which contains suggestions for improvements for each waste in the casting process of CV. Wishitama:

Table 4.4 Proposed Improvements for CV. Wishitama Casting Process

	Waste	Factor	Cause	Proposed Improvements
Overprocessing	Repairing leaking, damaged or improper formwork	Man	Workers were not careful when installing formwork	Increase direct supervision when workers are working on installing formwork. This prevents the installation of formwork by workers who do not meet company standards, thereby reducing the possibility of reinstallation.
			Not all workers are competent	Conduct additional training for workers who are less competent in installing formwork. This will improve the standard of workers and reduce the possibility of reinstalling formwork.
			Exhausted workers	Conducting evaluations of working hours and worker turnover. This is to avoid workers who are tired and overworked.
		Milieu	Land conditions suddenly change	Rechecking just before pouring the concrete into the formwork to see if the soil conditions are appropriate and not changing the formwork that has been installed. This is to reduce the possibility of additional repairs due to soil conditions.
	Repairing cracked or unsatisfactory concrete results	Man	Workers do not immediately use the vibrating tool immediately after the cast is poured.	Conduct direct supervision during the vibrating process and provide additional education on the importance of using vibrating tools directly during casting. This is done to reduce the possibility of workers delaying the use of vibrating tools. So it is hoped that the resulting concrete does not need to be repaired.
			Workers do not implement procedures properly	Implement a reward or punishment system according to worker performance regarding the proper implementation of vibrating tool procedures.
		Milieu	Bad weather	Cannot be controlled by the company
Queues	Waiting for preparation for casting location	Machine	Concrete pump had problems during setup	Perform maintenance for the concrete pump machine used in the casting process periodically. This is to check and ensure that the condition of the concrete pump is in good condition for use. Thus reducing the possibility of waiting because you have to fix the concrete pump while the casting process is taking place.

		Man	Slow preparation of concrete pump installation	Planning an efficient schedule so as not to interfere with other activities. Then, supervision and feedback also need to be done so that the preparation of the upcoming concrete pump installation has less waiting time with results that meet standards.
			Not all workers are competent	Assign workers who have the capability in concrete pump installation to reduce errors that occur. This is expected to reduce installation errors, thereby reducing waiting time due to installation errors and installation repairs.
		Milieu	The casting location is still used operationally	Coordinate with related parties regarding effective schedules and solutions. In addition, establish clear work zones to separate areas being worked on and areas still in use to avoid queues and disruptions.
	Delay in arrival of heavy equipment to the project location (readymix and concrete pump)	Milieu	The terrain is difficult for heavy equipment to access	Conducting outreach with related parties around the location to provide adequate road access and placement of heavy equipment to avoid delays due to difficult to access terrain.
			Congested road	Prepare plans and analyze the best route to the project location to avoid traffic jams on the road.
Defective product	There was a leak in the installed formwork	Man	Formwork installation was not carried out by competent workers	Conduct additional training for workers who are less competent in installing formwork. This will improve the standard of workers and reduce the possibility of reinstalling formwork.
			Exhausted workers	Conducting evaluations of working hours and worker turnover. This is to avoid workers who are tired and overworked.
		Milieu	Land subsidence during casting	Rechecking just before pouring the concrete into the formwork to see if the soil conditions are appropriate and not changing the formwork that has been installed. This is to reduce the possibility of additional repairs due to soil conditions.

	There are hairline cracks in the dry concrete	Man	The compaction process using a vibrating tool is not carried out directly during casting.	Conduct direct supervision during the vibrating process and provide additional education on the importance of using vibrating tools directly during casting. This is done to reduce the possibility of workers delaying the use of vibrating tools. So it is hoped that the resulting concrete does not need to be repaired.
			Casting work was not carried out according to the proper method	Implement a reward or punishment system according to worker performance regarding the proper implementation of vibrating tool procedures.
		Milieu	Bad weather	Cannot be controlled by the company
Motion	Difficulty in maneuvering at the casting location during vibrating	Man	There are too many workers at the casting site	Conducting an evaluation of the number of workers who should be in the field and who should not. This is expected to increase the space for workers who are directly responsible at the casting location.
			Lack of worker awareness of the lack of space to move around on site	Melakukan sosialisasi kepada pekerja bahwa hanya pekerja yang bertanggung jawab saja yang perlu berada di lokasi pengecoran. Pekerja yang tidak bertanggung jawab bisa melakukan pekerjaan lainnya atau menunggu arahan selanjutnya dari pengawas proyek.
			Not all workers get vibrating tools	Conducting evaluation and re-coordination of the distribution of vibrating tools for each worker. This is done to ensure that the number of vibrating tools and workers in charge does not exceed capacity.

Future stream mapping can be described after mapping the current state mapping of the casting process, assessing each identified waste, connecting with the seven-value stream mapping tools, analyzing with process activity mapping, and considering proposed improvements. The future stream mapping in Figure 4.6 is the result of eliminating waste that occurs in the current state mapping of the previous casting process. The waiting time that occurs due to waiting for heavy equipment at the beginning of the process is eliminated so that workers can immediately start preparation activities. Then, the inefficiency of the spreading process towards the vibrating process is eliminated. Workers

must prepare the vibrating tool from the beginning, not between the spreading process towards the vibrating process.

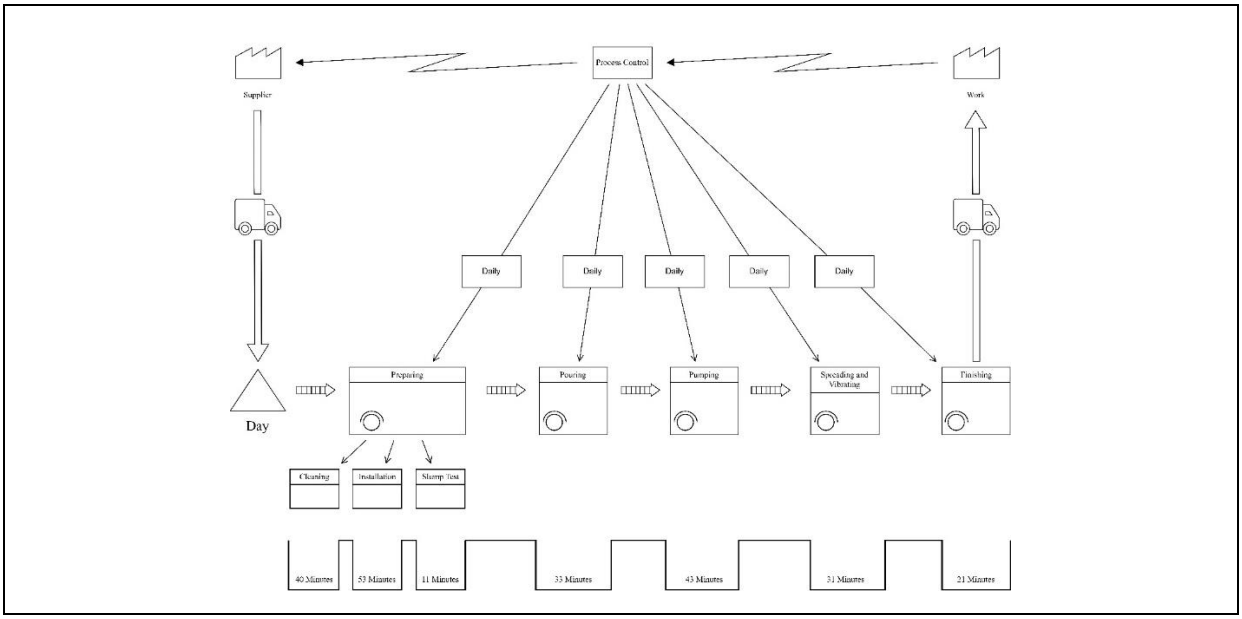

Figure 4.6 Future Stream Mapping Casting Process

This research can provide a significant impact that can be done by company managers to reduce waste and increase efficiency in the casting process carried out by CV. Wishitama. The company needs to ensure that the company can survive in the onslaught of this competitive industry, this can be realized by using the resources available as efficiently as possible and reducing waste that can cause problems in operations in the casting process. Therefore, managers can carry out quality improvement strategies based on waste identification in the casting process and previous improvement proposals.

The main thing to do is to eliminate waste that causes overprocessing. Managers must eliminate activities that do not add value to reduce unnecessary waiting time. Managers also need to provide additional training, supervision, and evaluation of workers to ensure that the work results are in accordance with the standards desired by the company. This is done to reduce the mismatch of the final results that cause overprocessing and must be improved again. Thus, the results of this study are expected to help the company achieve its goals in the future.

5. Conclusion

The purpose of this study is to identify waste that occurs in the casting process of the project carried out by CV. Wishitama and to provide suggestions for improvements to the casting process of the project carried out by CV. Wishitama. After going through interviews and analysis processes using value stream analysis tools (VALSAT) and fishbone diagrams, the author can provide the following conclusions:

1. Based on the current state mapping of the casting process, there are several points that are the reasons for the delay. The casting process begins with waiting for the arrival of heavy equipment, preparing which consists of cleaning, installation, and slump test, then pouring, pumping, spreading, vibrating, and finishing. Delays occur while waiting for heavy equipment

and between the spreading and vibrating processes. Based on waste assessment and interviews, several wastes with the highest priority were identified, namely overprocessing with an average value of 4.5 and defective products, queues, and motion with an average value of 4. Based on the analysis of the seven value stream mapping tools, process activity mapping is used to identify problem points and optimize them because they have the highest relationship value of 162. Based on the analysis of process activity mapping, the activities to be eliminated are 2 activities that are included in the delay category with a percentage of 14% of the total time and 2 activities that are included in the non-value adding (NVA) type with a percentage of 14% of the total time. Then these activities can be divided into overprocessing, queues, defective products, and motion. Waste that includes overprocessing is repairing leaking, damaged, or inappropriate formwork and repairing cracked or inappropriate concrete results. Waste that includes queues is waiting for preparation for the casting location and the delay in the arrival of heavy equipment to the project location (readymix and concrete pump). Waste that includes defective products is leakage in the installed formwork and there are hairline cracks in the dried concrete results. Waste that includes motion is the difficulty of moving space at the casting location when vibrating.

2. Improvement proposals are given based on the root cause of the problem that occurs from the results of the analysis using a fishbone diagram. The priority for making changes is based on how many factors occur for each waste. Therefore, improvement proposals are given sequentially starting from the man, milieu, and machine factors. Improvement proposals for the man factor are that the company can increase direct supervision, conduct additional training, conduct evaluations, implement a reward or punishment system according to worker performance, plan an efficient schedule, assign workers as needed, and conduct socialization of current worker performance. Improvement proposals for the milieu factor are that the company can recheck before continuing the process between processes and coordinate with local parties regarding road access and activity locations that are still in use. Improvement proposals for the machine factor are that the company can periodically maintain the machines and heavy equipment used in the casting process. From the results of these proposals, the researcher also provides an overview of the future stream mapping used by the company. Future stream mapping is described by eliminating the activity of waiting for heavy equipment and combining spreading and vibrating activities.

After going through interviews and analysis processes using value stream analysis tools (VALSAT) and fishbone diagrams, the author can provide the following suggestions:

1. As an effort to reduce waste that occurs and realize effectiveness, the company can consider implementing improvement proposals little by little. Changes do not need to be made all at once, but rather periodically. The man factor is the main focus by implementing direct supervision, conducting additional training, conducting evaluations, implementing a reward or punishment system according to worker performance, planning an efficient schedule, assigning workers according to needs, and conducting socialization of current worker performance. After that, the milieu factor is considered by rechecking before continuing the process between processes and coordinating with local parties regarding road access and activity locations that are still in use. The last factor that must be considered is the machine factor with periodic maintenance of machines and heavy equipment used in the casting process. These actions are expected to be carried out by the company to reduce the recurrence of each cause of waste that occurs in the casting process of CV. Wishitama.

2. The researcher realizes that this study has limitations and shortcomings in its discussion and analysis. Therefore, the researcher provides suggestions for further research. Further research can conduct analysis with the same method to analyze the casting process in more detail such as the start of reinforcement to maintenance/curing. In addition, analyzing other processes carried out by CV. Wishitama can also be done. These other processes include painting, roof installation, electrical installation, and other processes.

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