AN IMPLEMENTATION OF LEAN CONCEPT WITH 5S TO ELIMINATE MATERIAL WASTE IN PRECAST FACTORY

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ABSTRACT

Precast industry is currently experiencing an increase in demand from consumers. Due to increasing demand, a wide variety of products, and push production systems, factories suffer from excess waste, disorganized workplaces, and unhealthy working environments. In overcoming this problem, research was carried out by implementing a lean concept with Seiri, Seiton, Seiso, Seiketsu, Shitsuke (5S) on the handling of waste materials that occur in the precast concrete production process. Material waste is obtained from interviews and analysis of the production cost budget assisted by the Pareto 80/20 method to determine materials that are cause residual cost. Then the results are re-analyzed with cause analysis based on the results of brainstorming with a production manager. Two material wastages were obtained, namely wire and formwork console oil, then will be repaired with the seiri concept in the form of making a warehouse near the work area. This improvement will eliminate material wastage that it can save oil. 2930-liter console formwork oil and 5915 kilograms of wire, with a total cost savings of IDR 123,758.060,00.

***Keywords**: 5S, Efficiency, Lean Concept, Pareto*

1. INTRODUCTION

Precast concrete enables construction to create high-quality structures at a low cost using durable and quickly assembled prefabricated elements. [1]. The use of precast concrete has several advantages, such as speeding up construction, improving quality, reducing project costs, improving sustainability, and improving occupational safety [2]. Because of these benefits, the precast industry is currently experiencing an increase in demand from consumers. Due to increasing demand, a wide variety of products, and push production systems, factories suffer from excess waste, disorganized workplaces, and unhealthy working environments. [3]. So, it needs a method to overcome these problems, one of which is applying the lean concept.

Simultaneous implementation of sustainable construction and lean concepts/practices is feasible with a strategic approach to achieving improved waste reduction, leading to positive environmental and economic consequences [4]. Lean Concept has several methods in its application, such as VSM, 5S, SMED, Kanban, Jidoka, Hoshin Kanri, Leveling, Standardized Work, Poka-yoke, and Kansai Shiro, Kanban, and Kaizen Philosophy. [5]. this study will focus on the application of 5S to overcome the problem of material waste. Seiri, Seiton, Seiso, Seiketsu, and Shitsuke (5S) are lean concept improvement methods applied to reduce waste, clean the workplace, improve labor productivity and achieve more consistent operational results and the system [6].

This study will also use the Pareto method to determine materials that are included in the waste category. The Pareto principle has been implemented in various of fields, because of its validity and usefulness, such as in the fields of economics, biology, ethology, and civil engineering [7]. Pareto's theory focuses on a significant minority, claiming that 80% of the project's outcomes are determined by 20% of its elements [8]. The Pareto method can analyze and determine the dominant types of materials that cause waste [9].

There are several research have done before which revealed lean concept can minimize material waste. Caldera resulted lean thinking can be adopted as a targeted approach to construct sustainable business models that reduce waste and improve material efficiency, and minimize costs in business processes [10]. Vilventhan resulted A waste generation rate of 66.26kgm−2 was identified from a building construction case study, and almost 90% waste from concrete, cement mortar, and brick. A lean strategic framework has been developed showing synergistic benefits to be gained in combining lean construction literature with the C&D waste literature [11]. Kodheir concluded that using this tool can affect the environmental sustainability by reducing material waste by 64% in gypsum board hanging process, and the economic dimension by reducing working hours by 31% in the interior painting process. Social dimension was accomplished by increasing worker safety and a 15% improvement in value-added activities [12]. Shidu concluded 5S has an improved impact on the elimination of material waste and management of materials, tools, equipment, and etc [13].

However, they have not explicitly considered the overall strategy of lean implementation. This study offers modification of work process by implementing a lean concept using the 5S concept at precast factory to eliminate material waste obtained from pareto analysis.

2. RESEARCH METHOD

The initial step is determining the problems. In this step applied in this research is the interview process with the quality control and quantity surveyors to determine the problems in each material, which is supported by field observations to find out the supporting data that causes these problems to occur. Output from this stage are stock quantity data, material usage and residual cost of each material.

The second step is analysis using Pareto's method. The Pareto method used is Pareto Law 80/20, which is used to determine which material will be analyzed further based on percentage of residual costs obtained from the first stage. Output of this stage is obtained materials that are included in the Pareto Law 80/20, for further analysis of the causes.

The third step is cause analysis. This analysis aims to dig deeper into the selected material from the previous results, to get the root cause of the problem that arises, and whether the material is included in the waste category or not. this analysis process is accompanied by academics and production managers to determine the root cause of the material, and whether the waste can still be used with certain tests or should be discarded because it does not meet the standards. The output of this stage is obtained materials that are included in the waste category which will then be repaired with 5S.

The last step is Improvement with 5S analysis. At this stage, an analysis of alternative improvements will be carried out to eliminate the waste. After obtaining alternative improvements, simulations will be carried out to obtain output in the form of the impact of these improvements on materials and costs.

3. RESULT AND DISCUSSION

3.1. Residual Cost Analysis

The residual cost analysis is a calculation to get the cost of the remaining material that has been obtained from the calculation of the difference between the available material and the used material which is then multiplied by the unit price of the material, which can be seen in Table 1.

Table 1. Residual Cost Analysis

Materials	Unit	Unit Price (IDR)	Stock	Used	Remains	Residual Cost (IDR)	Percentage (%)
		a	b	c	d = b - c	e = a * d	
Sand	m3	258.750	890,16	432,17	457,99	118.504.594	20,98
Split 1-2	m3	229.500	661,01	577,60	83,41	19.142.134	3,39
OPC Cement	Ton	820.000	130,39	101,96	28,43	23.308.500	4,13
Additive Console P 300 - 2	Liter	21.500	1520	1220,94	299,06	6.429.801	1,14
PC Strand 12.71	Liter	13.700	46374	43470	2904	39.784.800	7,04
Reinforcement Ø 8	Kg	7.800	9960,00	6189,00	3771,00	29.413.800	5,21

Materials	Unit	Unit Price (IDR)	Stock	Used	Remains	Residual Cost (IDR)	Percentage (%)
Reinforcement Ø 13	Kg	7.450	28546,63	9660,20	18886,43	140.703.889	24,91
Console Formwork Oil	Liter	14.250	3800	870	2930	41.752.500	7,39
Wire	Kg	13.864	6340	425	5915	82.005.560	14,52
BCT	Kg	37.667	1830	1350	480	18.080.160	3,20
Oxygen	Tube	47.000	84	78	6	282.000	0,05
Coal	Kg	1.000	33670	25200	8470	8.470.000	1,50
Diesel fuel	Liter	11.900	4860	1760	3100	36.890.000	6,53

From the results of the analysis above, the costs and also the percentage of each material are obtained for further analysis using the following Pareto method.

3.2. Pareto Analysis

After obtaining the percentage for each material, it is then illustrated with a Pareto Law 80/20 diagram to get what materials are included in the 80/20 area, where the material included in that area will be selected as the material with the largest residual cost, which will be shown in Figure 1.

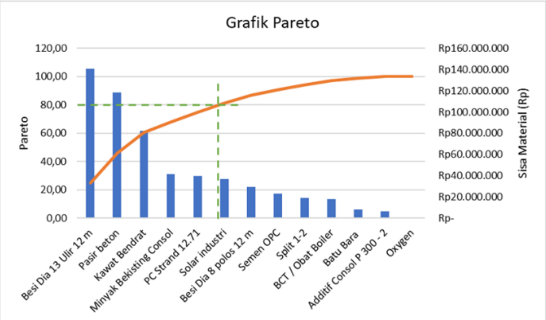

Figure 1. Pareto's Diagram

In the picture above, the right axis shows the cumulative percentage, the left axis shows the cost of waste material, and the bottom axis shows the materials that cause waste. From the diagram above, it can be seen, that if a straight line is drawn on the axis 80% to cut the curve line, then the point of intersection is drawn downwards, namely towards the material axis, it will be found that the dominant material is included in the Pareto's Law concept 80/20, which is a cumulative value of 80%, including Reinforcement Ø 13, Concrete Sand, Wire, Consol Formwork Oil, and PC Strand 12.7. So that the total residual cost for the five dominant types of material is Rp. 422,751,342.00.

3.3. Cause Analysis

From the results of the analysis using the Pareto method, it was found that 5 types of material were waste, including reinforcement Ø 13, concrete sand, wire, console formwork oil, and PC strand 12.7. In the following Table 3 will be analyzed the causes of excess costs based on the results of observations and interviews which shown as Table 2.

Table 2. Cause Analysis Results

materials	Cause residual cost
Reinforcement Ø 13	Reinforcement has deteriorated or is damaged due to storage for too long. Excess purchase quantity due to inaccurate estimation of needs.
Concrete sand	Stock hoarding is intentionally done to avoid cost increases and save delivery time.
Wire	Wire has decreased quality or is damaged due to storage for too long.
Console formwork oil	Oil has decreased in quality due to storage for too long. Damage to the oil due to direct exposure to the weather in the storage area
PC Strand 12,7	Unskilled or inexperienced workers Excess purchase quantity due to inaccurate estimation of needs

From the analysis above and the results of the interview, it was found that the concrete sand was intentionally stocked more to avoid price increases and save delivery time, and the stockpiling did not reduce the quality of the sand. For reinforcing materials, and PC Strand 12.7, it is necessary to do a corrosion test to determine whether the material is still suitable for use or not. Wire and formwork console oil have a great potential for quality damage due to improper storage, for example being exposed to rainwater so that the wire will rust and the oil will mix with water. So that obtained 2 materials that cause residual costs, namely wire and formwork oil console with a cost of IDR. 123,758,060.00.

3.4. Improvement with 5S

Improvements with 5S will apply the first value, namely seiri. Seiri is an activity to get rid of items that are not needed and make items that are needed easier, so that all items at the work site are only items that are really needed in work activities. In the results of the analysis, it was found that two materials were included as waste because of the lack of handling of these materials which caused damage to the quality of these materials and could not be reused. in this study only applies the impact of seiri, because from the results of this concept analysis, it has an influence on the problem of material waste.

In the current site layout, there is actually a storage area (Figure 2) which is indicated by the symbol C, but it has a considerable distance from the work area indicated by the symbol G, so that stacking is carried out in the work area which aims to eliminate added time due to taking materials. From these problems, improvements will be made which can be seen in **table 3**.

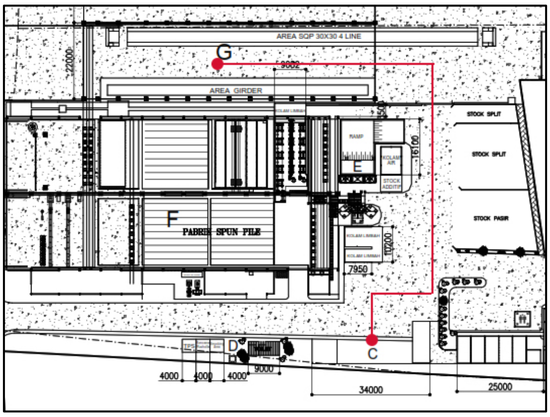

Figure 2. Site Layout

However, placing the material near the work area in addition to causing the work area to become narrow, also causes the material to be exposed without any protection or cover causing damage due to weather or from heavy equipment and workers and can also cause potential work accidents.

Figure 3. Work Area Condition

Table 3. Seiri Improvement

Problems	Improvements
Stock of reinforcing material is piled up in the work area, which causes disruption to the production flow and is also prone to damage due to being stepped on by workers, being hit by tools, and rusting or quality degradation due to lack of protection.	Making a storage area for materials in addition to protecting the quality of the material, it is also to protect workers from causing work accidents due to a narrow work space.

Warehouse construction is planned near the reinforcement fabrication area to make it easier for reinforcing workers to take reinforcing stock, and also the selection of the location by considering the traffic conditions of work in the surrounding work area so as not to disrupt the work flow. The location of the warehouse will be indicated by a red box in **Figure 4**.

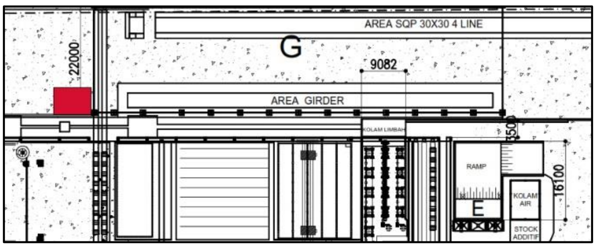

Figure 4. Warehouse Location

This warehouse was designed to accommodate material and equipment, especially formwork console oil and wire, so that damage does not occur due to the work process or due to weather, as modeled in **Figure 5**.

Figure 5. Warehouse 3D Model

4. CONCLUSION

From the results of the analysis obtained two materials that are included in the waste category, namely Formwork Console Oil and Wire. Both of these wastes will be overcome by the seiri method in the form of making a temporary warehouse to protect the material from weather and work activities due to indiscriminate laying. This improvement will later result in Formwork Console Oil savings of 2930 liters and wire of 5915 kilograms, and cost savings of IDR 123,758,060.

This study has limitations in its analysis in the form of focusing on only one type of concrete, namely CCSP concrete, so for further research to be able to analyze all materials used in the production process in order to produce significant savings.

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