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Strategy of Change Construction Method to Increase Productivity and Reduce Waste in the Private University Buildings

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Abstract. In the effort of productivity management of floor plate formwork method and minimising waste in building projects, the contractor must know the level of productivity of conventional floor plate formwork method and panel floor formwork method. Aim of this research is to explore the strategy of increasing productivity by three objectives: (1) measuring productivity of the implementing floor plate formwork among two methods, (2) analysing the productivity ratio based on first objective through productivity factors 5M (Method, Material, Machine, Man Power and Money) on building projects, (3) analysing waste in the comparison between 2 methods. The research method used was a case study of a university building project in Yogyakarta. Strategy to answer the research objectives, this research was occupied productivity analysis through these two methods. The results showed that productivity of the floor panel formwork method is higher that is 595.84 m²/day and labour productivity is 36.67 m²/person per day, compared to productivity of conventional formwork method is smaller that is 385.13 m² per day, and labour productivity is 27.03 m² /person per day, and panel floor plate formwork can minimize waste in lean construction assessment board assessment

1. Introduction

Technology in the world of construction in Indonesia is growing more rapidly, which is marked by the increasing number of innovations in the implementation of multi-storey building construction projects. One application of technology used is in the form of floor plate formwork. Construction of high-rise buildings has now begun to be built, such as the construction of hotels, apartments, offices, and hospitals. One of them is the construction of two buildings of a university in Yogyakarta. Formwork work in the two buildings uses two different techniques. The first building uses conventional formwork techniques, while the second one uses floor panel formwork techniques.

The difference in the use of formwork engineering methods in the construction of these two university buildings in Yogyakarta also affects productivity, human resource needs, materials,



machinery, and costs. Conventional floor plate formwork and floor plate formwork have their respective advantages and disadvantages, which significantly affect productivity and waste problems.

Fitriyah's study [1] stated that the problem in the construction industry recently is the occurrence of inefficiency in the project implementation process caused by the many non-value added activities or often called waste that can harm the construction industry such as transportation, use of materials, waiting, or unemployed labour. This research aim to elaborate the impact of strategies change method of floor plat formwork in two buildings where the lean construction assessment employed as justification.

2. Literature review

Productivity is a measure of the output of the production process of each unit. Productivity is measured by a comparison between output and input. Productivity can also be defined as a measure of the efficiency of production being carried out. Another understanding of productivity according to Wignjosoebroto [2] is the ratio between outputs per input. In order to increase productivity, it is necessary to strive for the production process to be able to contribute fully to productive activities related to added-value and try to avoid or minimize unproductive activity steps such as idle or delays, set-up and loading-unloading.

Heizer and Render's study [3] explains that there are some methods used to measure work productivity. However, this measurement is also challenging to be conducted accurately. Therefore, some approaches are usually carried out to measure productivity. Measuring productivity with only one resource as input is called as single-factor productivity. Increasing productivity possibly intervention by humans. Conversely, human resources can cause waste and inefficiency in various forms [4].

Koskela *et.al.* in Abdelhamid [5] states that lean construction is a way to design a production system to minimize waste and time, and also to produce maximum value. The benefits of lean construction techniques have been demonstrated by the improved achievement of many projects and each stage of the project. Lean construction requires more time in the design and planning stages, but this attention eliminates or minimizes conflicts that can dramatically change costs and schedules [6].

In internal assessment of the contractor's company, there are the data of "lean construction assessment board". There are nine criteria in the assessment: defects, overproduction, waiting, non-Utilizing employees, transportation, inventory, motion, extra-processing, and cost improvements. The lean construction assessment consists of four quarters time during a project to find out the extent of the improvement.

3. Research method

This research uses a descriptive quantitative method accompanied by field observation and interviews with quality control officer on the project site. The data collection was taken during the construction process. Thus, the information of the formwork setting-up are corroborated by daily and weekly report of the project documentation such as S curves and implementation cost aspect. In order to obtain valid and actual data from the object of study both primary and secondary. Furthermore, after obtaining the necessary data, productivity analysis is carried out from the two-floor plate formwork methods and analysing waste using lean construction assessment board from secondary data of the project.

4. Result and discussion

The result of the productivity calculation of the conventional floor plate formwork and the panel floor formwork methods show different results in the two methods. Then the productivity calculation of the conventional floor plate formwork method with the panel floor plate method is compared. The comparison determines the results of differences between the two methods so that it can be concluded the highest level of productivity. The productivity calculation considered by 5M of productivity factors namely Method, Man Power, Money, Machine and Material.

4.1 Method

Calculation result using the panel floor formwork method shows higher than the conventional method. Table 1 shows the difference in productivity between panel method and the conventional method.

Table 1. The comparison of Conventional floor plates formwork methods with panel method

Laboratory Building (Panel method)					Medical Building (Conventional method)				
Week	Workers	Sum of Days	Real Vol. (m ²)	Productivity m ² /day	Week	Workers	Sum of Days	Real Vol. (m ²)	Productivity m ² /day
A	b	c	d	e=d/c	a	b	c	d	e=d/c
16	29	4	679.92	169.98					
17	<i>Not available data</i>								
18	53	4	694.93	173.73	13	36	4	522.13	130.53
19	44	4	806.01	201.50	14	36	4	80.85	20.21
20	45	4			15	36	4	372.36	93.09
21	45	4	1,693.50	423.37	16	36	4	141.76	35.44
22	60	4	231.16	57.79	17	36	4	456.93	114.23
23	58	4	811.33	202.83	18	53	4	789.87	197.47
24	63	4	2,086.65	521.66	19	57	4	1,540.52	385.13
25	65	4	1,327.81	331.95	20	48	4	455.32	113.83
26	65	4	2,383.34	595.84	21	59	4	1,234.99	308.74
27	<i>Idul Fitri Vacation</i>				22	<i>Idul Fitri Vacation</i>			
28	<i>Idul Fitri Vacation</i>				23	<i>Idul Fitri Vacation</i>			
29	70	4	546.44	136.61	24	51	4	665.92	166.48
30	85	4	1,324.00	328.50	25	51	4	1,317.35	329.34
31	76	4	1,562.61	390.65	26	58	4	852.37	213.09
32	55	4	1,545.40	386.35	27	33	4	407.22	101.80
33	50	4	596.69	149.17	28	61	4	1,414.27	353.57
34	36	4	194.33	48.58	29	61	4	497.45	124.36
35	36	4	1,090.16	272.54	30	46	4	809.85	202.46
36	38	4	595.69	149.17	31	22	4	376.44	94.11
37	40	4	350.21	87.55	32	24	4	998.31	249.58
38	45	4	1,663.55	415.87					
39	48	4	660.24	165.06					
40	60	4	498.95	124.74					
41	59	4	383.37	95.84					
42	55	4	414.21	103.55					

4.2 Man power

Table 2. The comparison of labor productivity of conventional floor plate formwork with panels

Week	Laboratory Building (Panel)							Medical Building (Conventional)													
	Workers	Sum of Days	Real Vol. (m2)	Produktivitiy m ² /day	Produktivitiy of worker group Person/day	Week	Workers	Sum of Days	Real Vol. (m2)	Produktivitiy m ² /day	Produktivitiy of worker group Person/day	Week	Workers	Sum of Days	Real Vol. (m2)	Produktivitiy m ² /day	Produktivitiy of worker group Person/day				
a	b	c	d	e=d/c	f=b/c	g=e/f	a	b	c	d	e=d/c	f=b/c	g=e/f	a	b	c	d	e=d/c	f=b/c	g=e/f	
16	29	4	679.92	169.98	7	23.45															
17							<i>Not available data</i>														
18	53	4	694.93	173.73	13	13.11	13	36	4	522.13	130.53	9	14.50								
19	44	4	806.01	201.50	11	18.32	14	36	4	80.85	20.21	9	2.25								
20	45	4					15	36	4	372.36	93.09	9	10.34								
21	45	4	1,693.50	423.37	11	37.63	16	36	4	141.76	35.44	9	3.94								
22	60	4	231.16	57.79	15	3.85	17	36	4	456.93	114.23	9	12.69								
23	58	4	811.33	202.83	15	13.99	18	53	4	789.87	197.47	13	14.90								
24	63	4	2,086.65	521.66	16	33.12	19	57	4	1,540.52	385.13	14	27.03								
25	65	4	1,327.81	331.95	16	20.43	20	48	4	455.32	113.83	12	9.49								
26	65	4	2,383.34	595.84	16	36.67	21	59	4	1,234.99	308.74	14	20.93								
27							<i>Idul Fitri Vacation</i>														
28							22							<i>Idul Fitri Vacation</i>							
29	70	4	546.44	136.61	18	7.81	24	51	4	665.92	166.48	13	13.06								
30	85	4	1,324.00	328.50	21	15.46	25	51	4	1,317.35	329.34	13	25.83								
31	76	4	1,562.61	390.65	19	20.56	26	58	4	852.37	213.09	14	14.70								
32	55	4	1,545.40	386.35	14	28.10	27	33	4	407.22	101.80	8	12.34								
33	50	4	596.69	149.17	13	11.93	28	61	4	1,414.27	353.57	15	23.18								
34	36	4	194.33	48.58	9	5.40	29	61	4	497.45	124.36	15	8.15								
35	36	4	1,090.16	272.54	9	30.28	30	46	4	809.85	202.46	11	17.61								
36	38	4	595.69	149.17	10	15.70	31	22	4	376.44	94.11	10	9.41								
37	40	4	350.21	87.55	10	8.76	32	24	4	998.31	249.58	12	21.24								
38	45	4	1,663.55	415.87	11	36.97															
39	48	4	660.24	165.06	12	13.75															
40	60	4	498.95	124.74	15	8.32															
41	59	4	383.37	95.84	15	6.50															
42	55	4	414.21	103.55	14	7.53															

The calculation result using the panel floor formwork method shows the work per worker per square meter is higher than using the conventional method. The difference in result from the two labour productivity calculations using the method is influenced by the method being used.

4.3 Money

The calculation result using the panel floor formwork method shows a lower cost in term of the need for two-storey formwork of Rp. 3,120,702,160.41 and the need for formwork repairs to Rp 921,779,957.48. Compare to the cost of implementing the conventional floor plate formwork method shows that the cost is more expensive in terms of the need for two-story formwork is Rp.3,916,322,583.43, and the need for formwork repair is Rp.1,879,264,895.16. The difference between the implementation costs for the two methods is Rp. 1,753,105,360.71 and the difference is about 1.71%.

4.4 Machine

Conventional floor plate formwork with panel floor formwork shows that there is a difference in the method of panel formwork method that is the existence of welding equipment. Welding tools in this method are used to carry out welding work on the framed formwork in the fabrication location. The panel floor formwork installing in advanced on the workshop. Whereas the use of equipment in conventional formwork method uses ordinary tools because in this method, cutting and forming formwork are carried out at the job site while the floor plate is in progress. The detail of equipment can be seen in table 3.

Table 3. The comparison of equipment between conventional and panel method

Conventional method		Panel method	
1	Saw	1	Saw
2	Hammer	2	Hammer
3	Pliers	3	Pliers
4	Meter	4	Meter
		5	Welding

4.5 Material

Based on figure 1, the comparison of conventional floor plate formwork and panel floor panel formwork shows different result. The result of the panel floor formwork method shows that the material is used before the implementation of floor plate work begins.

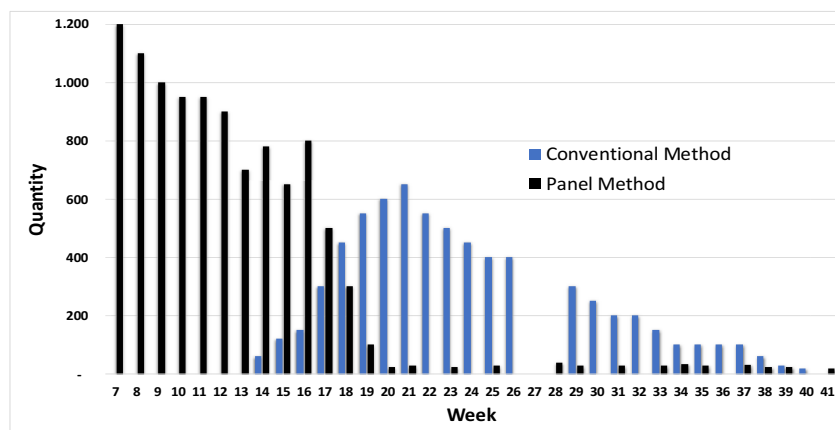


Figure 1. The comparison of conventional floor plate formwork and panel materials

The material is first made into a panel in the pre-fabricated location while the use of conventional floor plate formwork material shows the material is used when the floor plate work begins. Based on Lean Construction Assessment Board, the result of the assessment can be seen in figure 2.

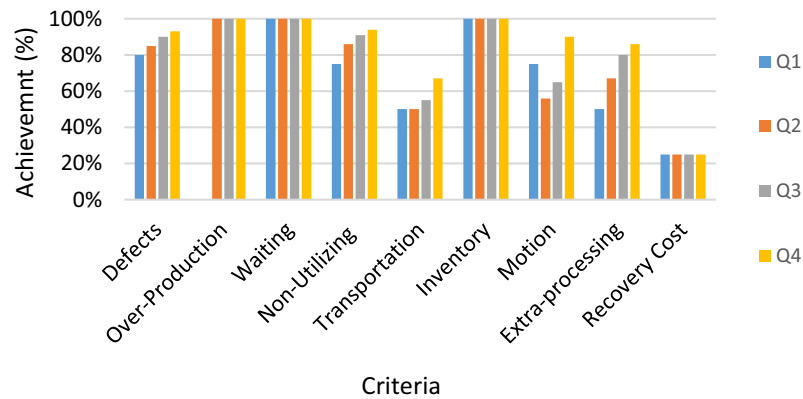


Figure 2. Lean construction assessment board

Based upon the lean construction assessment board, the percentage from the first quarter to the fourth quarter shows an increase in the average percentage. In the first quarter the average percentage is 80%, the second quarter the average percentage is 85%, the third quarter the average percentage is 90%, and the fourth quarter the average percentage is 93%. Thus, the efforts of minimizing waste, especially in the work of panel floor plate formwork contained in the criteria of defect items can be overcome

5. Conclusion

In panel formwork method, the productivity is higher than conventional method. The effort of minimising waste, the panel floor formwork method can be overcome in the lean construction assessment board. In order to support increased building project productivity and minimise waste, in this case, changes in work methods for floor plate formwork to use panel floor formwork. Thus, increasing productivity by the strategies of change method shows a significant impact, either waste or cost aspect.

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