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Analysis of Productivity Loss In Ironing, Formwork, and Casting Work at Summarecon Mall Bandung Project

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ABSTRACT

In a developing country such as Indonesia, infrastructure development is one of aspects that contribute to advancement for the country. However, construction industry in Indonesia has a problem regarding to low construction productivity. Lean construction regarded as the new method to improve construction performance and labor productivity. Using two principles of lean construction, benchmarking and labor production variability reduction will be analyzed to show how impact it caused to labor performance. Benchmarking will be used to analyze for Summarecon Mall Bandung Project with parameters of Disruption Index (DI), Perfomance Ratio (PR) and Project Manajemen Index (PMI). The project has DI<0,1 score that means abnormality days that happened was low, varied PR score in all construction operation, and low PMI score that represent good construction management system. In conclusion based on all parameters, Mall Summarecon Bandung Project is relatively good project and can be used as a benchmark for similar construction project.

Introduction

The main issue in the construction sector globally is that the resulting productivity has not experienced a significant change (only 1% increase) when compared to the manufacturing industry which can provide a change of 3.6% over the last two decades. According to the McKinsey Global Institute, if these key issues can be corrected, the construction sector could have the opportunity to increase value added by $1.6 trillion USD. Therefore, it is necessary to do things that can improve conditions in this construction sector (Abdel-Razeq & Hashem, 2020).

In developing countries like Indonesia, infrastructure development is something that is being intensified for the progress of the country. Infrastructure progress will also improve the welfare of human life. Therefore, the construction sector is an important sector to improve. However, the construction industry, especially the Indonesian state, still has problems regarding low construction productivity (Abduh, Soemardi, & Cakravastia, 2013).

Many studies have been conducted around the world in order to increase construction labor productivity, for example: studies on factors affecting construction labor productivity, measuring and evaluating labor productivity, modeling construction labor productivity, comparing construction labor productivity (benchmarking), and comparing work productivity based on economic or cost considerations (Barbosa, Woetzel, & Mischke, 2017).

Through many studies that have been conducted, it has been found that in recent years, the principle of lean construction has received a lot of attention as a new way to improve construction performance and labor productivity. The benchmarking method itself is also an important framework in research in the national and global construction markets. In 1999 Thomas and Zavrski developed a framework to measure construction labor productivity internationally and can be used to benchmark construction labor productivity in certain construction activities. The application of this benchmarking can lead to an evaluation of labor productivity and identify the best and worst performing projects (Thomas, Horman, De Souza, & Zavřski, 2002).

Poor management and other factors that can lead to unnecessary changes in construction can lead to variality of performance. Reducing variability in labor productivity will result in improved labor performance. Therefore, benchmarking and reducing labor productivity variability are two of the most important lean construction principles that will be examined in this paper to demonstrate their impact on workforce performance (Tommelein, 1998).

The purpose of this study is to determine the benchmarking and variability of worker productivity in the Summarecon Mall Bandung Phase II project, the impact of worker productivity loss that occurs, and how solutions to reduce the impact of worker productivity loss.

1. Productivity

(Thomas & Mathews, 1986) note that there is no standard definition of productivity, and according to (Oglesby & Erickson, 1989) although many have defined productivity in construction, there is no universally accepted definition. Researchers concluded that due to the complexity and unique characteristics of construction projects, it is difficult to obtain a standard method for measuring construction productivity. But in general, productivity is generally a comparison between the results of activities (outputs) and inputs (inputs). Productivity can also be interpreted as the success rate of operations as measured by the ability of systems, humans or machines to produce products efficiently and effectively according to plan. In construction, productivity is measured during a construction project and can be a ratio of cost, time, labor, materials and tools. According to (Silalahi, 2004), the productivity of construction work can be measured by paying attention to the number of workers employed. Meanwhile, according to (Wignjosoebroto, 1995), labor productivity in construction is a comparison (ratio) between input and output. With construction projects consisting of a variety of simple and complex tasks, productivity becomes a very important thing to pay attention to. In construction activities, high productivity is needed so that work can be completed at the lowest possible cost and as quickly as possible.

2. Lean Construction

Introduced by (Koskela, 1992), with the aim of improving the performance of the construction industry by referring to the manufacturing industry with its Lean Production approach. The philosophy is further developed by the community of construction researchers and practitioners who are members of the Group for Lean Construction

(IGLC). Focusing on the production process in the field, with the existence of the Last Planner System (LPS), and until now has penetrated into the implementation of holistic construction with its Integrated Project Delivery (IPD) (Anggasta & Prasetya, 2022).

3. Lean Construction Principle

In essence, lean construction is the application of lean principles applied to the manufacturing industry to the construction industry with the aim of increasing value and reducing waste. The principles of lean are as follows (Womack and Jones, 1996):

- **Value.** The definition of value must be very specific and carried out by the end customer.
- **The Value Stream**. It must be designed in such a way that there is a movement of defined value from one activity to another, starting from problem-solving activities at the beginning, then to information management activities, and to transformation activities from raw materials to final products.
- **Flow**. The transfer of values must be done in a flowing manner, there are no obstacles.
- **Pull**. To avoid unused products, and reduce waste, products should be produced when requested by users.
- **Perfection**. Activities to improve all processes continuously must be carried out to achieve perfection.

Meanwhile, according to Koskela, Ballard, Tommelein, and Thomas. The principles of lean construction are:

- Practice Just In Time (JIT)
- Use pull-driven scheduling.
- Reduce variability in labor productivity.
- Improving flow reliability.
- Eliminate waste, and simplify the operation.
- Benchmarks.

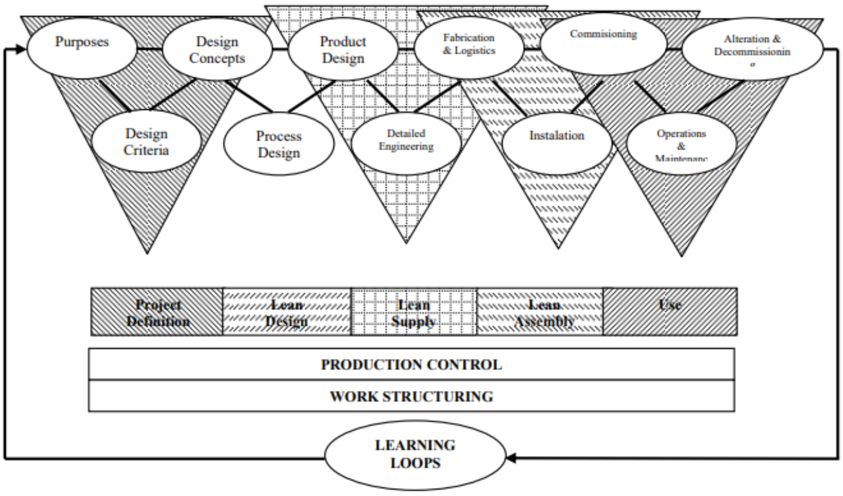


Figure 1 Lean principles

4. Difference Between Traditional Production and Lean Production

a. Traditional Production

- The production process is the conversion of inputs into outputs.
- The conversion process can be divided into sub-processes, which are also conversion processes.
- The total cost of the process can be minimized by minimizing the cost of each sub-process.

- The output value of a process is associated with the input costs for that process.

Points 3 and 4 suggest that in order to minimize costs, attention should be focused on cost management in each operation and sub-process. Value on the other hand doesn't really matter. The output value can be increased by using better materials and more skilled labor, the cost of which is higher (Haruna, Usman, Oraegbune, Muhammad, & Bamidele, 2017).

b. Lean Production

Lean construction systems view production as the flow of materials, information, equipment, and labor from raw materials to products. In this flow, material is converted, inspected, waited or moved. Processing that describes the conversion aspect of a production; Checking, moving and waiting represent aspects of production flow. In essence, the lean production model consists of conversion and flow processes. The overall efficiency of production is due to the level of efficiency of conversion activities carried out and the efficiency of activity flow. All activities that cost money and time, ensured only value adding activities. The core idea of lean production is to reduce or eliminate non-value adding activities and increase the efficiency of value adding activities (Jeyamathan, 2012).

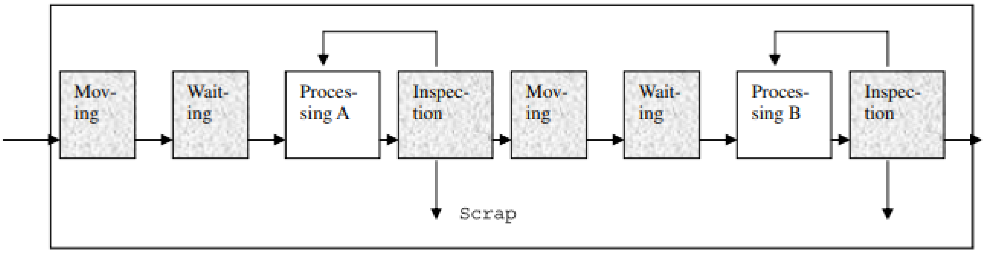


Figure 2 Production Flow

5. Benchmarks

Benchmarking can be defined as a systematic and continuous measurement process; a process of continuously measuring and comparing an organization's business processes with business leaders anywhere in the world to gain an informed advantage that will help the organization to take action to improve its performance. Benchmarking can be internal, external, classic, traditional, process, performance, functional, strategic or a combination. The idea behind each method is the same: to identify, measure, compare, conduct gap analysis, adapt and implement new ideas (Nugroho & Sunbara, 2021).

In this paper labor productivity is defined as the working hours of work divided by the units of work completed. The benchmark is to compare labor productivity in one project with another. The following are project atrributes that need to be measured for benchmarking

1. Total workhours : The sum of the daily working hours in each project
2. Total quantities : The sum of the total daily work volumes in each project
3. Cummulative productivity : A measure of the overall effort required to install a job
4. Cummulative productivity: $\frac{\text{Total workhours (h)}}{\text{Total quantities (m}^2\text{)(pekerjaan bata)}}$
5. Number of abnormal workday: random variability in daily productivity values in the absence of distractions is about double the baseline productivity. Values that exceed this limit are usually the result of interference. An important measure of performance is the number of abnormal or interrupted days
6. Baseline productivity: the best performance a contractor can achieve for a particular design.

6. Reduce Variability

The variability of daily labor productivity greatly affects project performance. Variability in productivity is the determinant of both good and poor performing projects. Therefore, to improve performance can be done by reducing the variability of labor productivity (Cim, Bahrun, Magribi, & Ode, 2020).

Research Methods

This research was conducted using data analysis and interviews from the Summarecon Mall Bandung Phase II project by PT Jagat Konstruksi Abdipersada, as for the flow diagram of research work as follows:

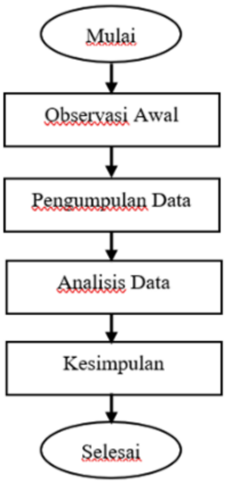


Figure 3 Research Method Flow Chart

After initial observations and obtaining research data in the form of the number of working hours and volume of work on the project, followed by the calculation of productivity, disruption index (DI), performance ratio (PR), project management index (PMI), and productivity variability. The data obtained was then used to analyze how much productivity loss in the Summarecon Mall Bandung project.

To calculate productivity in hours of unity of the volume of work used the following formula

$$Cummulative\ productivity: \frac{Total\ workhours\ (h)}{Total\ quantities\ (m^2)}$$

Where:
Total workhours: The sum of the daily work hours in each project
Total quantities: The sum of the total daily work volumes in each project
Cummulative productivity: A measure of the overall effort required to put up a job

Next, calculate the disruption index (DI), which is the ratio of the number of disrupted working days divided by the total number of observed working days.

$$Disruption\ index\ (DI) = \frac{Number\ of\ abnormal\ (disrupted)\ work\ days}{Total\ number\ of\ work\ days}$$

DI values range from 0-1. The higher the DI, the more projects experience abnormal workdays which means that a lot of work is disrupted and this is a bad thing.

Then calculate the performance ratio (PR) value, obtained by the actual cumulative productivity value divided by the expected baseline productivity (baseline average value of all projects)

$$PR = \frac{Cumulative\ productiviy}{Expected\ baseline\ productivity}$$

The PR value will describe a good construction work performance if the PR value is lower.

Project management index (PMI), a dimensionless parameter that reflects the effect of project management on cumulative workforce performance.

$$PMI = \frac{Cumulative\ productivity - Baseline\ productivity}{Expected\ baseline\ productivity}$$

The PMI value is a dimensionless parameter that reflects the contribution of project management to cumulative workforce performance on the project. The lower the PMI, the better the effect of project management on overall performance. Higher numbers indicate poorer labor performance.

In addition to the three parameters above, managing labor productivity variability is a dimension that is no less important than lean thinking. Calculate the variability of labor productivity of the project under study and study the relationship between variability and performance performance. A smaller CV value will show that it performs well and there are not many interruptions or abnormal work in the project. The calculation of CV value can be seen in the following formula

$$Coefficient\ of\ variation\ for\ project\ (CV_j) = \frac{V_j \times 100}{(Baseline\ productivity)_j}$$

$$Variaton\ (V_j) = \frac{\sum \sqrt{(ur_{ij} - baseline\ productivity_j}^2}{n}$$

Where:

CV_j : Coefficient of variation for Project J

ur_{ij}: the daily productivity (unit rate) for workday I on project j

n : the number of workdays on project j

Results and Discussion

Data collection consists of ironing work activities (3 foremen), foundries (2 foremen) and formwork (2 subcontractors) from the Summarecon Mall Bandung Phase 2 construction project. The field visit and data were obtained from PT Jagat Konstruksi on November 1, 2022. The project includes a mall building consisting of 5 floors and is semi-open. During the field visit, it was found that the construction process had reached the 2nd floor of the mall. Table xxx shows data in the form of project name, project location, type of workforce, number of workers, and amount of work time successfully collected.

The table also shows data that has been calculated for further research, namely total hours worked, total cumulative productivity, and basic productivity of each project. The cumulative productivity of the projects studied ranged from 0.00141 to 0.83086.

The average baseline productivity of this project is 150 kg/day/person for ironing work, 15 m3/day/person for foundry work, and 15 m2/day/person for formwork. While the criteria for an abnormal working day (abnormal day) is a day when there is a disruption in the form of workers who suddenly return home without informing so that the team from the foreman is not fully present. Through interviews, it was obtained from the results of abnormal day estimates about 2 days a week.

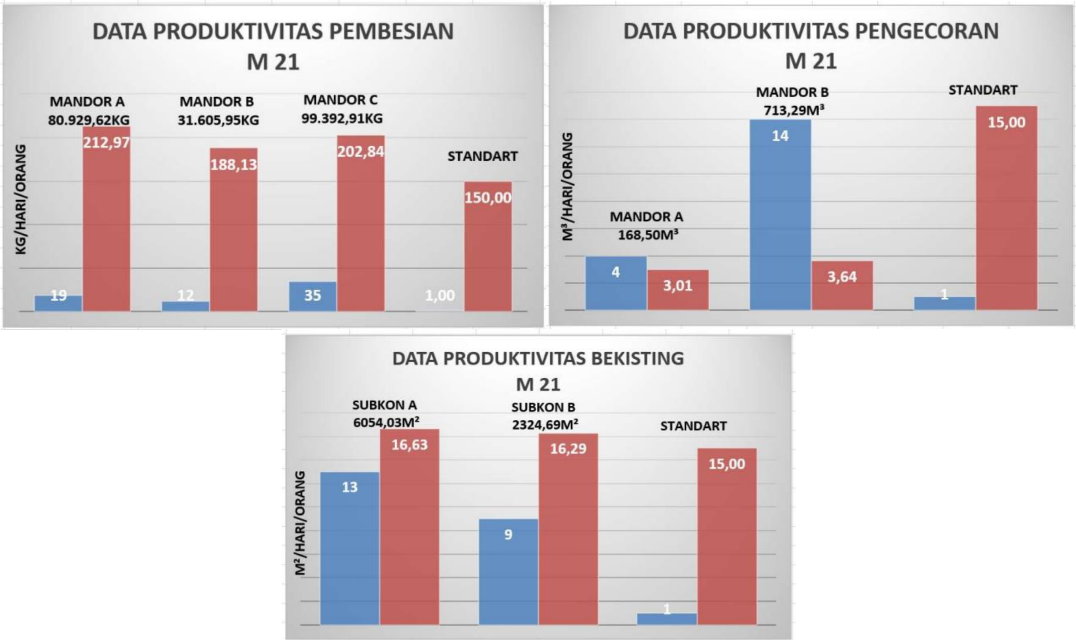


Figure 3 Productivity of each construction operation of Summarecon Mall Bandung

Project performance parameters (benchmarks)

Disruptions index (DI): has a range of values from 0.0 to 1.0. The higher the DI score, the more abnormal work days (poor projects) can be known. For example, for ironing work, it was found that the DI value owned by foreman A was the smallest, which was 0.002. This shows that the work done by foreman A is the best job, because in addition to having a very small DI value (DI<0.1) but the DI value obtained by foreman A is the smallest compared to foremen B and C, which is 0.002857. Overall, both ironing, foundry, and formwork work have a very small DI value (DI<0.1) means that it can be said that the project at Summarecon Mall Bandung has a good performance in terms of treating abnormal work days. This clarifies the data obtained when conducting interviews on how site managers can spur foremen to keep their teams compact and royal when it's time to work. The method used to maintain the motivation of foremen and subcons is known to be in the form of rewards or incentives that will be given if they can work well and do not interfere with the course of the project. For more details, further studies can be carried out related to what kind of solution strategy is used by PT Jagat Konstruksi to keep abnormal work days low and can collaborate with foremen and sub-contractors.

Performance ratio (PR): A lower PR value will explain that the work or project has better performance. A PR value greater than 1 does not mean the project is underperforming, but rather is a relative comparison to the best overall performance observed across all work on the project. For example, the foundry work done by foreman A and foreman B have PR values of 4.99 and 4.12. This job has a very high PR value so it has productivity that is less than baseline productivity. This shows that further analysis needs to be done as to why this happened and what caused the poor performance of the foundry work carried out by foreman A and foreman B. As for ironing and formwork work as a whole has a low PR value (PR<1.0), this shows that ironing and formwork work already has good performance and this clarifies the data obtained during the interview, namely from PT Jagat Konstruksi providing tents and shade so that workers can continue to work in all conditions for ironing work and for formwork work they have used removable casings Quickly like Lego.

Table 1 Parameter Assessment of Each Construction Operation of Summarecon Mall Bandung

Pekerjaan Pembesian				
Data	Observasi			
	Mandor A	Mandor B	Mandor C	Rata-Rata
Volume (kg)	80929.62	31605.95	99392.91	70642.827
Durasi (hari)	20	14	14	16
Jumlah Pekerja	19	12	35	22
Produktivitas Pekerja (kg/hari)	4046.48	2257.57	7099.49	4467.85
Produktivitas Pekerja (kg/hari/org)	212.97	188.13	202.84	201.32
Produktivitas Standard (kg/hari/org)	150	150	150	150
Total Work Hours (Jam)	200	140	140	160
Cummulative Productivity (h/kg)	0.00247	0.00443	0.00141	0.00277
Baseline productivity (h/kg)	0.00351	0.00556	0.00190	0.00366
Abnormal Days	4	4	4	4
DI	0.02000	0.02857	0.02857	0.02571
PR	0.70432	0.79732	0.73949	0.74704
PMI	-0.29568	-0.20268	-0.26051	-0.25296

Pekerjaan Pengecoran			
Data	Observasi		
	Mandor A	Mandor B	Rata-Rata
Volume (kg)	168.5	713.29	440.895
Durasi (hari)	14	14	14
Jumlah Pekerja	4	14	9
Produktivitas Pekerja (kg/hari)	12.04	50.95	31.50
Produktivitas Pekerja (kg/hari/org)	3.01	3.64	3.32
Produktivitas Standard (kg/hari/org)	15	15	15
Total Work Hours (Jam)	140	140	140
Cummulative Productivity (h/kg)	0.83086	0.19627	0.51357
Baseline productivity (h/kg)	0.16667	0.04762	0.10714
Abnormal Days	4	4	4
DI	0.02857	0.02857	0.02857
PR	4.98516	4.12175	4.55345
PMI	3.98516	3.12175	3.55345

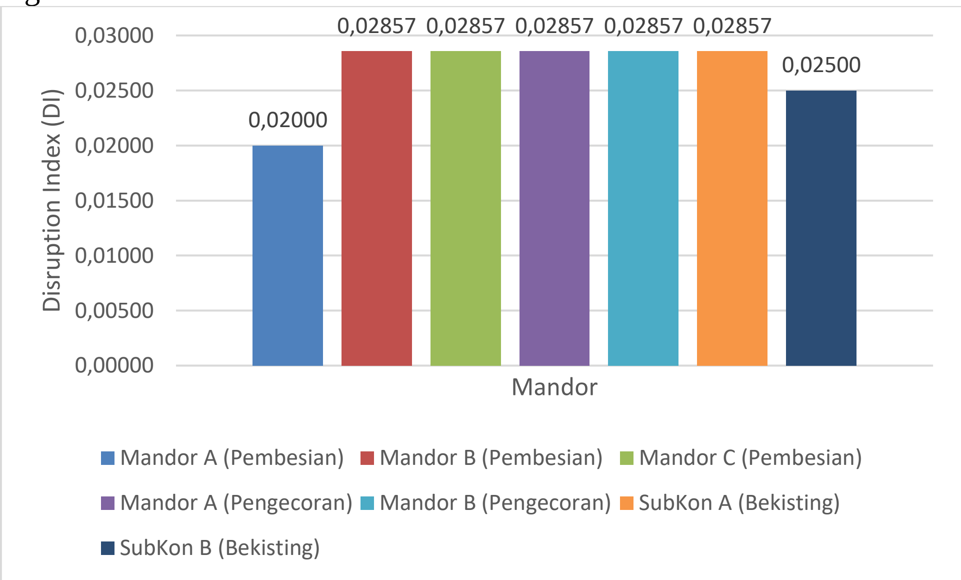
Pekerjaan Bekisting			
Data	Observasi		
	SubKon A	SubKon B	Rata-Rata
Volume (kg)	6054.03	2345.69	4199.86
Durasi (hari)	28	16	22
Jumlah Pekerja	13	9	11
Produktivitas Pekerja (kg/hari)	216.22	146.61	181.42
Produktivitas Pekerja (kg/hari/org)	16.63	16.29	16.46
Produktivitas Standard (kg/hari/org)	15	15	15
Total Work Hours (Jam)	280	160	220
Cummulative Productivity (h/kg)	0.04625	0.06821	0.05723
Baseline productivity (h/kg)	0.05128	0.07407	0.06268
Abnormal Days	8	4	6
DI	0.02857	0.02500	0.02679
PR	0.90188	0.92084	0.91136
PMI	-0.09812	-0.07916	-0.08864

Project management index (PMI): PMI is a dimensionless parameter that reflects the contribution of project management to cumulative workforce performance on project work. The lower the PMI, the better the effect of project management on overall performance. Higher numbers indicate poorer labor performance. A recapitulation of PMI values can be seen in the histogram chart below. For ironing and formwork work, it has a unique PMI value, which has a very small PMI value (PMI<0.4) and even negative values. This the author concludes can happen because the productivity of existing workers always exceeds the standard or baseline productivity planned by PT Jagat Konstruksi .

This is a good thing but means that it is necessary to evaluate the baseline productivity used.

Based on interviews and direct observation of the management function of the work performed, it was found that there is a good planning and control system for time, cost and quality, adequate supply of resources and good communication and evaluation. We found that contractors, owners, and subcontractors on these projects regularly collaborate to achieve the same goal. PT Jagat's ability to increase worker productivity and support good project management in the field is also shown by currently in the s-curve of PT Jagat Konstruksi work which is experiencing 13% ahead schedule. Because the PMI value is very low, this helps explain why PT Jagat was able to achieve the S-Curve ahead schedule by as much as 13%.

But beyond that, foundry work that has a large PR value also has a very large PMI value (PMI>0.5). Based on interviews and direct observations of the foundry work process, it was found that there were difficulties in managing the workforce. Frequent disruptions affecting work are weather and due to lack of materials caused by delivery delays, but PT Jagat has tried to address this and evaluated this with improved communication and improved supervision. If PT Jagat can solve the problems in foundry work, this may improve performance and further accelerate the project and increase the percentage ahead schedule in the s-curve.



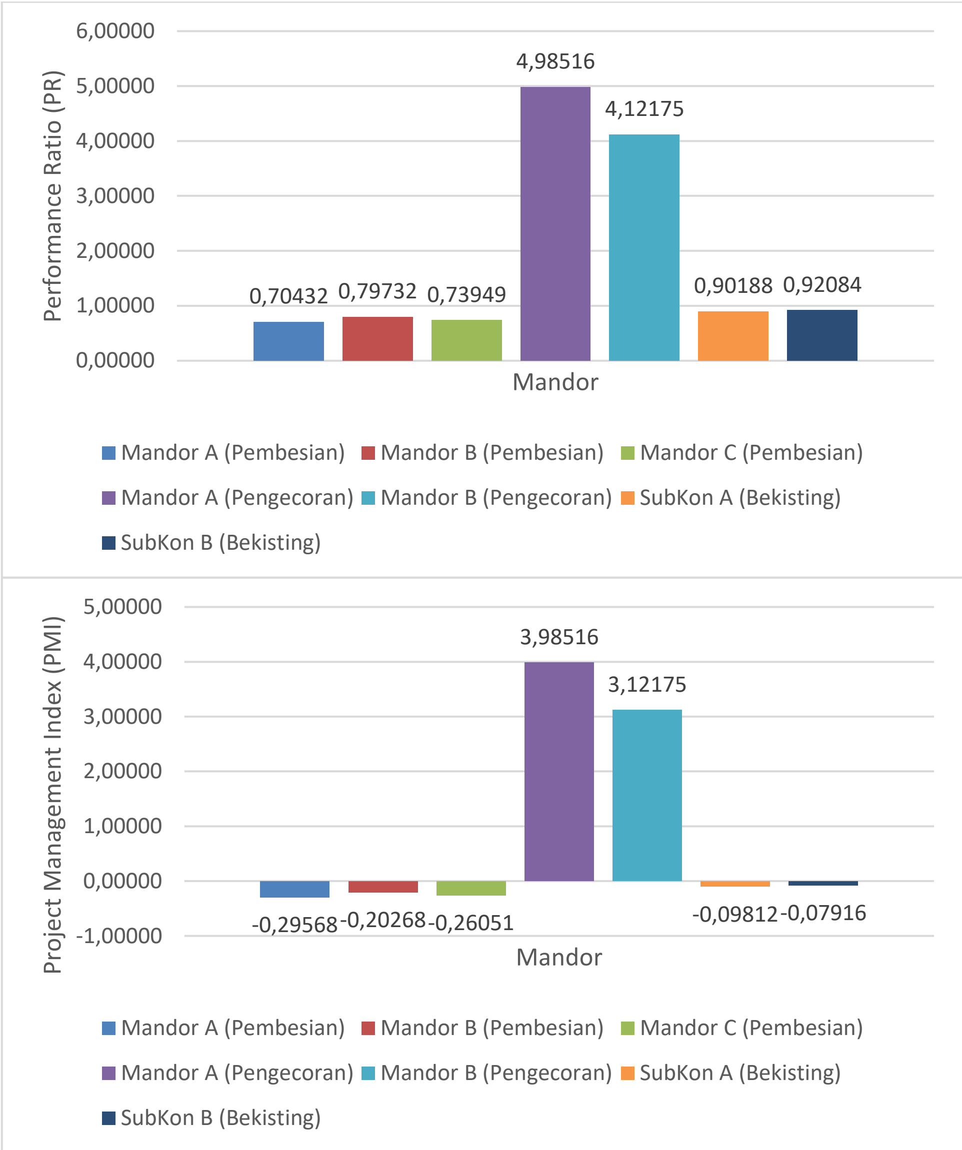


Figure 4 Parameter scoring curve for each group of foremen

Variability in daily productivity

Managing labor productivity variability is an important dimension of lean thinking. Then the second goal in this paper is to calculate the variability of labor productivity of the projects studied and study the relationship between variability and performance. However, because it requires data in the form of daily productivity, a number of workdays observations in the project. So that it experiences limited data obtained and cannot process further. In addition, if you want to collect your own data, it will take a long time, which is at least 5% of the total project time, which is not possible. But in principle, the value of the lower coefficient of variation (CV) (CV<65) will show that the project or work has productivity that tends to be stable and constant so that the project is managed properly. But the larger CV value (CV>100) then shows that the project is poorly managed because it has high variability. A high CV can also indicate that there are many abnormal workdays (variability of daily labor productivity). The way to lower variability is to improve workflow, better planning, and better communication and evaluation systems.

The relationship between variability and performance

In this section, the author plans to try to determine the value of the correlation coefficient from the coefficient of variation (CV) data of the project under study and the value of the project management index (PMI). The author's hypothesis is that CV and PMI have a large correlation coefficient value so that this shows that variability in daily productivity is highly correlated with project performance. The higher the value of variability in project productivity, it indicates poor project performance because there are fluctuations in labor productivity (many abnormal days are experienced).

Solutions that have been implemented by PT Jagat Konstruksi

The application of construction methods in the field is not always in accordance with the planning that has been drawn up by the planner. Based on the results of interviews with the PT Jagat Construction team, there are 2 types of methods used to control construction productivity, namely preventive and curative.

The preventive methods used by the PT Jagat Konstruksi team are:

- Implementation of Project Control, a productivity monitoring form is prepared as a reference for performance targets from the executor team and subcontractors. The form is also used as material for performance evaluation of implementers and becomes technical information in quality control and decision making. The monitoring form is recorded based on the progress of each implementing entity in completing the given target.
- Coordination Meeting, a meeting between PT Jagat and subcon is held in a weekly duration. At the coordination meeting, discussions were held on the evaluation of the performance of the implementers in the previous period and work plans for the next period. At this meeting, performance evaluations of each executive were also discussed which became the basis for making decisions to implementers to achieve predetermined performance targets. In addition, discussions were also held about problems that occur in the field and other factors that might affect the construction productivity of the implementation team.
- Reward & Punishment System, to spur the performance of the implementation team, the method is applied as a consequence of the performance results obtained. Awards are given to implementing teams that are able to achieve / exceed productivity targets.

Curative/repair methods that have been applied by the PT Jagat Konstruksi team are:

- Increasing productivity, if there is lagging progress due to variability such as unfavorable weather conditions or losses, then acceleration is carried out by increasing existing resources, both tools and labor. The addition of resources certainly results in additional costs, so negotiations are carried out with the implementation team for additional personnel or equipment. Increasing productivity also considers losses or penalties that may occur due to delays so that additional resources are added at a cost that has a lower value than the value of losses / penalties due to delays.

Conclusion

This research examines two principles of lean construction, namely benchmarking and reducing variability in labor productivity. By using labor productivity data from ironing, foundry, and formwork work in the Summarecon Mall Bandung construction project, the benchmarks that are calculated are disruption index (DI), performance ratio (PR), and project management index (PMI). These three parameters can accurately identify whether a project is performing well or poorly.

DI values range from 0.0 to 1.0. The higher the DI, the abnormal wordays (poor project). The DI value of the three jobs is very small (DI<0.1). Thus the sequence of work studied is a good project.

A good PR value is a lower PR value, then the project has a good performance compared to baseline productivity. Ironing and formwork work have a low PR (PR<1) so they are included in good work. While foundry work has a high PR (PR>1) so it is included in projects that have productivity below baseline productivity.

The lower the PMI value indicates the better the influence of project management on overall performance. Ironing and formwork work have a low PMI so they are included in jobs that have good project management. Meanwhile, foundry work has a high PMI so it is included in poorly managed work.

Variability in labor productivity (CV) is calculated and compared with project performance. Variability in daily productivity data cannot be calculated because it still lacks data and cannot test the authors' hypothesis of whether it can be an important delineator between good and bad performing projects. Because CV values cannot be calculated, they cannot be statistically correlated with project performance.

Solutions that have been implemented for PT Jagat Konstruksi are the implementation of project control for monitoring productivity targets, coordination meetings as an evaluation of the implementation team's performance and the basis for decision making, reward & punishment systems to maintain/spur the performance of the implementation team to achieve productivity targets, and additional productivity to maintain achievement of targets by considering the value of additional costs compared to with the value of losses that may be obtained in case of delay.

It can be concluded as a whole that the Summarecon Bandung Mall construction project is a good project and can be used as a benchmark for other projects and as learning material for other similar construction projects in Indonesia, namely in the form of buildings..

Bibliography

Abdel-Razeq, Hikmat, & Hashem, Hasan. (2020). Recent update in the pathogenesis and treatment of chemotherapy and cancer induced anemia. *Critical reviews in oncology/hematology*, *145*, 102837.

Abduh, Muhamad, Soemardi, Biemo W., & Cakravastia, Andi. (2013). The need of green construction supply chain management for delivering sustainable construction in Indonesia. *Second International Conference on Sustainable Infrastructure and Built Environment, Bandung*.

Anggasta, Najib Giovani, & Prasetya, Irfan. (2022). *Labor Productivity Analysis on Reinforced Concrete Foundation Works Reviewed from the Composition of The Working Group*.

Barbosa, Filipe, Woetzel, Jonathan, & Mischke, Jan. (2017). *Reinventing construction: A route of higher productivity*. McKinsey Global Institute.

Cim, Sunaryo, Bahrun, Andi, Magribi, Muh, & Ode, La. (2020). Productivity analysis and efficiency of concrete casting using mini-cranes with a capacity of 200 kg based on appropriate technology. *Revista de la construcción*, *19*(2), 198–208.

Haruna, A. C., Usman, N. D., Oraegbune, O. M., Muhammad, U. D., & Bamidele, O. (2017). Analysis of waste production on building construction sites: a case study of public institutional projects in Adamawa, Nigeria. *FUTY Journal of the Environment*, *11*(1), 55–63.

Jeyamathan, Jeyarajah. (2012). *Improving construction productivity with process value analysis (PV A): A study of formwork activities*. UNIVERSITY OF CALGARY.

Koskela, Lauri. (1992). *Application of the new production philosophy to construction* (Vol 72). Stanford university Stanford.

Nugroho, Rosalendro Eddy, & Sunbara, Angga. (2021). Work Accident Analysis in the Construction Project of PT. XYZ. *International Journal of New Technology and Research*, *7*(2).

Oglesby, Robert J., & Erickson, David J. (1989). Soil moisture and the persistence of North American drought. *Journal of Climate*, *2*(11), 1362–1380.

Silalahi, Bennet. (2004). Corporate Culture and Performance. *Copyright. Yayasan Pendidikan Al Hambra. Jakarta*.

Thomas, H. Randolph, Horman, Michael J., De Souza, Ubiraci Espinelli Lemes, & Završki, Ivica. (2002). Reducing variability to improve performance as a lean construction principle. *Journal of Construction Engineering and management*, *128*(2), 144–154.

Thomas, H. Randolph, & Mathews, Cody Terrell. (1986). *An analysis of the methods for measuring construction productivity*. [Construction Industry Institute, University of Texas at Austin.

Tommelein, Iris D. (1998). Pull-driven scheduling for pipe-spool installation: Simulation of lean construction technique. *Journal of construction engineering and management*, *124*(4), 279–288.

Wignjosoebroto, Sritomo. (1995). *Studi Gerak dan Waktu*. Edisi pertama, PT. Guna Widya, Jakarta.