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The Effectiveness of Using Excavator in the Construction Project of PT. Agro Plankan Lestari Palm Oil Factory, Sekadau Regency

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ABSTRACT

A construction project is a series of interrelated activities to achieve specific goals (buildings/construction) within a particular time, cost, and quality constraints. One crucial resource in this context is construction equipment or heavy machinery. West Kalimantan is renowned for its abundant palm oil production, including in Sekadau Regency. Due to the lack of palm oil processing factories, PT. Agro Plankan Lestari constructed a palm oil factory. The research findings indicate that the average performance efficiency of the excavator was 64% (considered good) for both excavators. However, the average Overall Equipment Effectiveness values for both operators were below the tolerance level set by the Japan Institute of Plant Maintenance (JIPM), which is 40%. The average overall equipment effectiveness values of excavator A obtained an average value of 39.82%, and excavator B obtained 41.69%.

Keywords: *Construction equipment efficiency, Palm oil factory construction, West Kalimantan, Overall Equipment Effectiveness (OEE), Heavy machinery performance*

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1. Introduction

Construction projects always require resources, including man, material, machine, method, money, information, and time. One crucial resource is construction equipment or heavy machinery. Heavy machinery, a familiar term in civil engineering, refers to mechanical equipment that aids humans in construction. The purpose of utilizing heavy machinery is to ease human tasks, facilitating more efficient and quicker achievement of expected results (Arif, 2018; Azzahra et al., 2023; Nuh et al., 2023; Syahrudin et al., 2023).

West Kalimantan is known for its abundant palm oil production, and one of the areas contributing to this is Sekadau Regency. In this region, PT has constructed a palm oil processing plant. Agro Plankan Lestari. The construction project for the palm oil plant in Sekadau utilizes heavy mechanical equipment such as excavators. Working hours are determined by the assessment of productivity in project work. If the operating hours of a machine are high, it can be predicted that the effectiveness or productivity of the machine is low (Maknunah L. et al., 2016). Good management planning in the use of heavy mechanical equipment is essential to determine the productivity value of the equipment and the required duration of equipment usage. Therefore, a specific review needs to be conducted

to understand the impact of equipment working hours on the effectiveness of resources, namely equipment, time, and costs.

2. Materials and Methods

The effectiveness of heavy machinery is analyzed using the Overall Equipment Effectiveness (OEE) method, which focuses on determining the effectiveness value of heavy equipment in a running project (Arifianty & Rumita, 2016). Parameters for the analysis are applied using the references from the Ministry of PUPR No. 28 of 2016 concerning heavy equipment for excavation work.

2.1. Research Location

Research is being conducted on PT's construction project for the Palm Oil Plant in Seberang Kapuas Village, Sekadau Hilir Sub-district, Sekadau Regency, West Kalimantan.

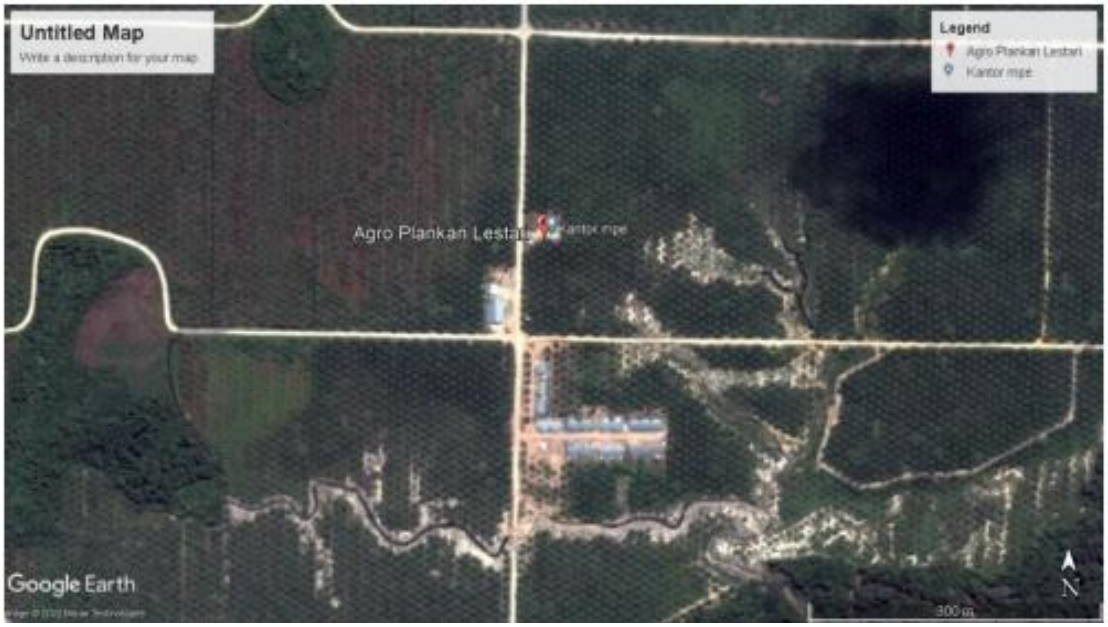

Figure 1. Project location (Google et al., 2022)

2.2. Data

Data is collected by reviewing two heavy machinery units, excavator A and excavator B. The required data for this research include:

a. Location data
b. Daily production data for heavy machinery
c. Heavy machinery data
d. References and literature related to heavy machinery from PT. Agro Plankan Lestari.

2.3. Analysis Method

Data that has been collected is subsequently processed for use in research analysis. The stages of data analysis conducted in this research are as follows:

2.3.1. Availability

$$\text{Availability} = \frac{operation\ time}{loading\ time} \times 100\% \quad (1)$$

Where:
Operation time = the actual working time of the equipment (minutes)
Loading time = the optimal working time of the available equipment per day (minutes)

2.3.2. Performance Ratio

Performance (%) = $\frac{proces\ amount\ x\ ideal\ cycle\ time}{operation\ time}$ x 100% (2)

Where:

Performance efficiency = the percentage of the production speed of heavy equipment per day (%)

Process amount = daily production (cubic meters)

Ideal cycle time = ideal operating time of the equipment (minutes/cubic meter)

Operation time = the actual working time of the equipment (minutes)

2.3.3. Quality Ratio

The quality ratio value in cut and fill operations is assigned a value of 100%. This is because cut and fill operations are not production activities that transform the initial product into the final one, commonly referred to as input (Ashar & Kayatun, 2018).

2.3.4. Overall Equipment Effectiveness (OEE)

The overall equipment effectiveness (OEE) value measures the effectiveness of a production operation. The analysis of calculating overall equipment effectiveness is obtained by multiplying the three OEE factors: availability, performance rate, and quality rate (Latif & Purnomo, 2019). The formula for the multiplication of these three factors is stated below

OEE (%) = *availability (%) x Performance ratio (%) x Quality ratio (%)* (3)

Table 1. Classification of OEE Value (*Japan Institute of Plant Maintenance*) (Wahyudi et al., 2016)

Value (%)	Description
≤100	Considered perfect, with flawless products, fast performance, and no downtime.
≤85	Considered good (global standard), suitable for the long-term planning of a company.
≤60	Considered fair, indicating significant room for improvement.
≤40	Considered low, but there is potential for improvement in the future.

2.3.5. Excavator Functions and Operation Mechanism

The productivity of the excavator can be calculated using the following formula:

Q = $\frac{q\ x\ 60\ x\ E}{Cm}$ $(\frac{m^3}{jam})$ (4)

Where:
Q = hourly production (m^3/hour)
E = job factor (equipment work efficiency (E))
q = production per cycle (m^3)
ql = bucket capacity
Cm = cycle time (minutes)
K = bucket factor

Table 2. Bucket Factor (Ministry of PUPR No. 28, 2016) (Syukroni, A., 2019)

Operation Condition	Field Condition	Bucket Factor (Fb)
Easy	Normal soil, clay, soft soil	1.1-1.2
Moderate	Normal sandy soil, dry	1.0-1.1
Somewhat Difficult	Normal rocky soil	1.0-0.9
Difficult	Crushed stone	0.9-0.8

Table 3. Cycle Time for Wheeled Backhoe (*Construction Methods & Management,* 1998)

Jenis Material	Equipment Size		
	0,76 m^3	0,94 – 1,72 m^3	>1,72 m^3
Gravel, sand, organic soil	0,24	0,30	0,40
Soil, clay, soft soil	0,30	0,375	0,50
Rock, hard clay	0,375	0,462	0,60

Table 4. Excavator Earthwork Conversion Factors (Ministry of PUPR No.28, 2016)

Excavation Condition (excavation depth/maximum depth)	Dumping Condition			
	Easy	Normal	Somewhat Difficult	Difficult
<40%	0,7	0,9	1,1	1,4
(40-75)%	0,8	1	1,3	1,6
>75%	0,9	1,1	1,5	1,8

Table 5. Equipment Efficiency Work Factors (E) (Ministry of PUPR No. 28, 2016)

Operation Condition	Efficiency Factor
Good	0.83
Moderate	0.75
Somewhat Less	0.67
Less	0.58

3. Result and Discussion

3.1 Calculation of *Availability Ratio*

The availability analysis determines the value of the time utilized to operate machinery or equipment. The availability calculation for excavator A on March 13, 2022, is as follows:

$$\text{Availability} = \frac{\text{operation time}}{\text{loading time}} \times 100\%$$

$$= \frac{480}{690} \times 100\% = 70\%$$

$$= 70\%$$

Using the same calculation method, Table 6 shows the availability ratio values for excavator A and B from March 13, 2022, to April 29, 2022.

Table 6. Calculation of Availability Ratio for Excavators A and B (Analysis Results)

Date	*Loading Time (minutes)* (X)		*Operation Time (minutes)* (Y)		*Availability Ratio (%) (Z)* (Y/X)	
	Exc. A	***Exc. B***	***Exc. A***	***Exc. B***	***Exc. A***	***Exc. B***
3/13/2022	690	690	*480*	466	*70%*	68%
3/14/2022	*690*	*690*	*480*	463	*70%*	67%
3/15/2022	*690*	*690*	*480*	456	*70%*	66%
3/16/2022	690	690	*480*	439	*70%*	64%
3/17/2022	*690*	*690*	*480*	460	*70%*	67%
3/19/2022	*690*	*690*	*480*	462	*70%*	67%
3/20/2022	690	690	*480*	453	*70%*	66%
3/21/2022	*570*	*570*	*420*	240	*74%*	42%
3/22/2022	*690*	*690*	*480*	360	*70%*	52%
3/26/2022	690	690	*480*	457	*70%*	66%
3/27/2022	*690*	*690*	*240*	420	*35%*	61%
3/28/2022	*690*	*690*	*480*	465	*70%*	67%
3/29/2022	690	690	*480*	461	*70%*	67%
3/30/2022	*690*	*690*	*480*	459	*70%*	67%
3/31/2022	*690*	*690*	*480*	454	*70%*	66%
4/1/2022	690	690	*300*	480	*43%*	70%
4/4/2022	*690*	*690*	*453*	456	*66%*	66%
4/5/2022	*570*	*570*	*397*	180	*70%*	32%
4/9/2022	*570*	*570*	*240*	509	*42%*	89%
4/10/2022	690	690	*446*	416	*65%*	60%
4/11/2022	*690*	*690*	*456*	429	*66%*	62%
4/12/2022	*690*	*690*	*462*	438	*67%*	63%
4/13/2022	*570*	*570*	*180*	360	*32%*	63%
4/14/2022	*570*	*570*	*339*	338	*59%*	59%
4/15/2022	690	690	*462*	446	*67%*	65%
4/16/2022	*690*	*690*	*467*	459	*68%*	67%
4/18/2022	*690*	*690*	*453*	452	*66%*	66%
4/20/2022	690	690	*453*	453	*66%*	66%
4/21/2022	*690*	*690*	*449*	459	*65%*	67%
4/23/2022	*690*	*690*	*360*	360	*52%*	52%
4/24/2022	*570*	*570*	*270*	360	*47%*	63%
4/25/2022	*570*	*570*	*150*	240	*26%*	42%
4/26/2022	*570*	*570*	*270*	360	*47%*	63%
4/27/2022	690	690	*330*	480	*48%*	70%
4/28/2022	*690*	*690*	*330*	480	*48%*	70%
4/29/2022	*690*	*690*	*513*	464	*74%*	67%

3.2 Calculation of *Performance Efficient Time*

Performance efficiency is measured as the ratio of the actual operational speed of the equipment to the ideal speed based on the equipment's capacity (Zulfatri et al., 2020). The calculation of the performance efficiency time for excavator A on March 13, 2022, is as follows:

$$\text{Performance Efficient} = \frac{\text{Proces amount x Ideal cycle time}}{\text{Operation time}} \text{ x } 100\%$$

$$= \frac{1090 \text{ x } 0{,}31}{480} \text{ x } 100\%$$

$$= 71\%$$

Table 7 provides the complete calculation of the performance efficiency for excavators A and B from March 13, 2022, to April 29, 2022.

Table 7. Calculation of Performance Efficiency for Excavators A and B (Analysis Results)

Date	*Process Amount (m^3) (X)*		*Working Hours (minutes)* (Y)		*Ideal Cycle Time (m^3) (Z)*		*Perform Ratio (P) = (X x Z)/ Y*	
	Exc. A	*Exc. B*	*Exc. A*	*Exc. B*	*Exc. A*	*Exc. B*	*Exc. A*	*Exc. B*
3/13/2022	1090	1090	480	466	0.31	0.29	71%	69%
3/14/2022	1243	1357	480	463	0.27	0.23	71%	68%
3/15/2022	863	1035	480	456	0.39	0.30	71%	68%
3/16/2022	1393	1393	480	439	0.24	0.21	71%	65%
3/17/2022	1465	1465	480	460	0.23	0.21	71%	68%
3/19/2022	1468	1355	480	462	0.23	0.23	71%	68%
3/20/2022	1370	1370	480	453	0.25	0.22	71%	67%
3/21/2022	334	334	420	240	0.94	0.32	75%	45%
3/22/2022	738	738	480	360	0.46	0.26	71%	54%
3/26/2022	1330	1330	480	457	0.26	0.23	71%	68%
3/27/2022	758	1137	240	420	0.12	0.23	38%	63%
3/28/2022	1365	1365	480	465	0.25	0.23	71%	69%
3/29/2022	1405	1405	480	461	0.24	0.22	71%	68%
3/30/2022	1195	1295	480	459	0.28	0.24	71%	68%
3/31/2022	1010	1875	480	454	0.34	0.16	71%	67%
4/1/2022	664	591	300	480	0.21	0.58	46%	71%
4/4/2022	1434	1544	453	456	0.21	0.20	67%	68%
4/5/2022	255	255	397	180	1.11	0.25	71%	35%
4/9/2022	525	735	240	509	0.21	0.62	45%	90%
4/10/2022	1227	1561	446	416	0.24	0.17	66%	62%
4/11/2022	1269	1269	456	429	0.24	0.22	68%	64%
4/12/2022	1464	1464	462	438	0.22	0.19	68%	65%
4/13/2022	352	293	180	360	0.18	0.80	35%	65%
4/14/2022	790	878	339	338	0.26	0.24	62%	61%
4/15/2022	1356	1469	462	446	0.23	0.20	68%	66%
4/16/2022	1390	1505	467	459	0.23	0.21	69%	68%
4/18/2022	1439	1439	453	452	0.21	0.21	67%	67%
4/20/2022	1468	1468	453	453	0.21	0.21	67%	67%
4/21/2022	1604	1234	449	459	0.19	0.25	67%	68%
4/23/2022	1061	1061	360	360	0.18	0.18	54%	54%
4/24/2022	593	593	270	360	0.23	0.39	50%	65%
4/25/2022	413	413	150	240	0.11	0.26	30%	45%
4/26/2022	615	615	270	360	0.22	0.38	50%	65%
4/27/2022	1145	1145	330	480	0.14	0.30	50%	71%
4/28/2022	1439	1439	330	480	0.11	0.24	50%	71%
4/29/2022	1464	1464	513	464	0.26	0.22	75%	69%

3.3 Calculation of Overall Equipment Effectiveness (OEE)

The Overall Equipment Effectiveness (OEE) value for the heavy equipment excavator is obtained by multiplying the three OEE factors: availability, performance ratio, and quality ratio. The calculation of the OEE for excavator A on March 13, 2022, is as follows:

OEE = Availability (%) x Performance Ratio (%) x Quality Ratio (%)

= 70% x 71% x 100%

= 49,28%

Table 8 shows the results of the OEE calculations for excavators A and B from March 13, 2022, to April 29, 2022.

Table 7. Recapitulation of OEE Values for Excavators A and B (Analysis Results)

date	*Availability Ratio % (X)*		*Perform Ratio%* (Y)		*Quality Ratio % (Z)*		*OEE value = (X x Y x Z)*	
	Exc. A	***Exc. B***	***Exc. A***	***Exc. B***	***Exc. A***	***Exc. B***	***Exc. A***	***Exc. B***
3/13/2022	70%	68%	71%	69%	100%	100%	49.28%	46.52%
3/14/2022	70%	67%	71%	68%	100%	100%	49.28%	45.95%
3/15/2022	70%	66%	71%	68%	100%	100%	49.28%	44.61%
3/16/2022	70%	64%	71%	65%	100%	100%	49.28%	41.44%
3/17/2022	70%	67%	71%	68%	100%	100%	49.28%	45.37%
3/19/2022	70%	67%	71%	68%	100%	100%	49.28%	45.75%
3/20/2022	70%	66%	71%	67%	100%	100%	49.28%	44.04%
3/21/2022	74%	42%	75%	45%	100%	100%	55.26%	18.95%
3/22/2022	70%	52%	71%	54%	100%	100%	49.28%	28.26%
3/26/2022	70%	66%	71%	68%	100%	100%	49.28%	44.80%
3/27/2022	35%	61%	38%	63%	100%	100%	13.04%	38.04%
3/28/2022	70%	67%	71%	69%	100%	100%	49.28%	46.33%
3/29/2022	70%	67%	71%	68%	100%	100%	49.28%	45.56%
3/30/2022	70%	67%	71%	68%	100%	100%	49.28%	45.18%
3/31/2022	70%	66%	71%	67%	100%	100%	49.28%	44.23%
4/1/2022	43%	70%	46%	71%	100%	100%	19.93%	49.28%
4/4/2022	66%	66%	67%	68%	100%	100%	44.04%	44.61%
4/5/2022	70%	32%	71%	35%	100%	100%	49.57%	11.05%
4/9/2022	42%	89%	45%	90%	100%	100%	18.95%	80.22%
4/10/2022	65%	60%	66%	62%	100%	100%	42.73%	37.35%
4/11/2022	66%	62%	68%	64%	100%	100%	44.61%	39.64%
4/12/2022	67%	63%	68%	65%	100%	100%	45.75%	41.26%
4/13/2022	32%	63%	35%	65%	100%	100%	11.05%	41.05%
4/14/2022	59%	59%	62%	61%	100%	100%	36.58%	36.37%
4/15/2022	67%	65%	68%	66%	100%	100%	45.75%	42.73%
4/16/2022	68%	67%	69%	68%	100%	100%	46.72%	45.18%
4/18/2022	66%	66%	67%	67%	100%	100%	44.04%	43.85%
4/20/2022	66%	66%	67%	67%	100%	100%	44.04%	44.04%
4/21/2022	65%	67%	67%	68%	100%	100%	43.29%	45.18%
4/23/2022	52%	52%	54%	54%	100%	100%	28.26%	28.26%
4/24/2022	47%	63%	50%	65%	100%	100%	23.68%	41.05%
4/25/2022	26%	42%	30%	45%	100%	100%	7.89%	18.95%
4/26/2022	47%	63%	50%	65%	100%	100%	23.68%	41.05%
4/27/2022	48%	70%	50%	71%	100%	100%	23.91%	49.28%
4/28/2022	48%	70%	50%	71%	100%	100%	23.91%	49.28%
4/29/2022	74%	67%	75%	69%	100%	100%	56.07%	46.14%
Total OEE Value							1433.36%	1500.85%
Average OEE							**39.82%**	**41.69%**

Based on the OEE calculations for excavators A and B, it is determined that the average OEE value for excavator A is 39.82%, and the average OEE value for excavator B is 41.69%.

4. Conclusion

Based on the analysis and data processing results, performance efficiency is deemed suitable, with an average of 64% for both excavators A and B. The analysis of OEE calculations reveals that some OEE values for each excavator are still below the standard tolerance value for OEE assessment, which is 40%, according to the Japan Institute of Plant Maintenance (JIPM). The average OEE value for excavator A is 39,82%, and the average OEE value for excavator B is 41,69%.

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6. Author's Note

The author declares consciously that this research is an original work and does not imitate any other research, as the results of this study have undergone examinations to obtain a Bachelor of Engineering degree from the Faculty of Engineering, Tanjungpura University.

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