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Analysis of the Productivity of Excavator and Dump Truck Heavy Equipment in the Excavation Works for the Construction of Jakarta MRT Station Cp 203 Phase 2A

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Abstract: The increasing demand for transportation infrastructure in urban areas such as Jakarta has led to the implementation of the Jakarta Mass Rapid Transit (MRT) Phase 2A project. One of the key components in this project is the efficiency of heavy equipment usage, particularly excavators and dump trucks, in excavation work. This study aims to analyze the productivity of excavators and dump trucks, calculate production per cycle, hourly production, daily production, and determine the optimal number of equipment units required to meet project completion targets.
The research method uses a quantitative approach by collecting primary data through field observations and interviews, as well as secondary data from project documents. The analysis results show that the Caterpillar 320 excavator has an actual productivity of 40.8 m^3/hour, while theoretical calculations indicate a productivity potential of up to 45.8 m^3/hour. To support the optimal operation of the excavator, four dump trucks with a capacity of 24 m^3 are required. This study provides recommendations for efficient allocation of heavy equipment to optimize project duration and cost.
This research is expected to serve as a technical reference for future infrastructure projects in planning heavy equipment requirements effectively.

Keywords: Productivity, Excavator, Dump Truck, Cycle Time, Jakarta MRT Project

INTRODUCTION

The development of the construction sector in Indonesia has shown a significant upward trend in recent decades, in line with national economic growth and the increasing need for public infrastructure that supports connectivity, mobility, and economic activities of the community. In metropolitan areas such as Jakarta, the development of a transportation system is a top priority for the government in order to overcome complex traffic problems. One of the solutions implemented is the development of a mass transportation mode based on rails, namely the Mass Rapid Transit (MRT), which is designed to be a fast, efficient, and environmentally friendly transportation alternative. The Jakarta MRT project is part of a national strategic program that aims to improve the quality of public transportation services while accelerating the movement of people in urban areas.

One of the important phases in this project is the construction of the Jakarta MRT Station CP 203 (Phase 2A), which crosses the Glodok to Kota area. This project has strategic value not only in terms of investment, but also in terms of technical challenges, especially in underground excavation work that requires effective and efficient heavy equipment planning. In the excavation process, the use of heavy equipment such as excavators as digging tools and dump trucks as transport tools are important components that must be combined optimally. The interaction of work between the two tools directly affects the smooth implementation of the project, both in terms of time and cost. Therefore, the analysis of the productivity of each tool is very necessary to achieve implementation efficiency and optimize the use of heavy equipment resources in the field.

Heavy equipment productivity is an important indicator in construction project management because it is directly related to production capacity, work duration, and resource utilization efficiency. However, in practice, there is often an imbalance between the working capacity of excavators and dump trucks which results in idle time and reduces operational efficiency. This imbalance is usually caused by a lack of study of work cycle time, actual production capacity, and the number of equipment units that match the volume of work and completion targets. In addition, a number of external factors such as field conditions, transportation distance, operator skill level, equipment efficiency, and material characteristics also affect heavy equipment productivity in real terms. Therefore, equipment performance estimates are not sufficient based on theory alone, but need to be accompanied by direct observations and measurements in the field to obtain actual data that is relevant to project conditions.

This study aims to analyze the productivity level of excavator and dump truck heavy equipment in excavation work in the Jakarta MRT Station CP 203 construction project. The main focus of the study is to calculate the actual productivity of both tools, compare them with theoretical standards, and evaluate the optimal working time based on project targets. The results of this study are expected to provide an empirical picture of the performance of heavy equipment in underground construction projects and become a technical reference for planning the use of heavy equipment in similar projects in the future.

Thus, analysis of heavy equipment productivity not only contributes to increasing technical efficiency, but also becomes an important strategy in supporting the achievement of overall construction project success.

RESEARCH METHODS

This research is a descriptive quantitative research with a case study approach, which aims to analyze the productivity of heavy equipment in the form of excavators and dump trucks in the excavation work of the Jakarta MRT Station Construction Project CP 203 Phase 2A. The population in this study were all project personnel involved in the operational and supervision activities of heavy equipment in the excavation work of the Jakarta MRT Station Project CP 203, especially those related to the use of excavators and dump trucks. This study uses a purposive sampling technique, which is a method of selecting respondents intentionally based on direct involvement in the implementation of heavy equipment work in the field and their competence in providing information relevant to the number of samples used in this study was 5 people consisting of 2 Excavator Operators, 2 Damp truck operators and 1 Field supervisor. This study aims to calculate the productivity of each tool, namely excavators/backhoes and dump trucks.

a. Performing Excavator/Backhoe Productivity Calculations

   To carry out productivity calculations of excavators/backhoes, researchers use the formula described below:

$$Q=\frac{60\ x\ q\ x\ E}{Ct}$$

b. Perform Dump Truck Productivity Calculations

   To carry out the calculation of dump truck productivity, researchers use the formula described below:

$$Q=\frac{60\ x\ q\ x\ E}{Ct}$$

c. Performing Standard Excavator Productivity Calculations

   To carry out the calculation of standard productivity of the excavator, researchers use the formula described below:

$$Q=\frac{V\ x\ Fa\ x\ Fb\ x\ 60}{Ts\ x\ Fv}$$

d. Performing Dump Truck Standard Productivity Calculations

   To carry out the calculation of standard productivity of dump trucks, researchers use the formula described below:

$$Q=\frac{V\ x\ Fa\ x\ 60}{Ts\ x\ D}$$

e. Duration of Work

So the formula used is explained below:

$$t=\frac{Vtotal}{Qdt}$$

RESULTS AND DISCUSSION

Survey Result Data

a. Project Identity

Project Name	:	Excavation Work for Construction of MRT Jakarta Station CP 203 Phase 2A
Location	:	Taman Sari Street, West Jakarta City
Contractor	:	PT.
Work	:	*Cut and Fill*
Execution time	:	105 days Covering GL – 2.5 m*depth*for 60 days, with a work volume of 12,480.00 m3 and 2.5 m depth – Top Slab for 45 days with a work volume of 9,563.18 m3

b. Heavy Equipment and Operator Data

1. Tool Name : Excavator/Backhoe
   Brand Type : Caterpillar Hydraulic Excavator 320
   Capacity : 1.00 m3
   Operator work experience : 13Year
   Effective Working Hours per day : 8O'clock
   Education : Vocational School

2. Tool Name : Dump Truck
   Brand Type : Dump Truck index 24 m3
   Capacity : 20.40 m3
   Operator work experience : 15year
   Effective Working Hours per day : 8O'clock
   Education : Vocational School

c. Project Schedule (Time Schedule)

Based on interviews conducted with parties who have responsibility within the scope of the project, it is known that the project completion schedule that was planned was 105 calendar days.

d. Excavation Volume

Based on the results of interviews with parties who have responsibility for the scope of the project, it is known that the excavation volume for the GL level - 2.5 m depth is 12,480 m3 and for 2.5 depth - top slab 9,563 m3 so the total is 22,043 m3.

Results

a. Backhoe Cycle Time

The following data was obtained through direct observation of the backhoe every day, with the aim of recording the backhoe work cycle time in seconds, which was then converted into minutes, as follows. The recapitulation of the excavator/backhoe cycle time on days 1-7 is shown in the following Table 1:

Table 1. Recapitulation of excavator/backhoe cycle time on days 1-7

Day 2-	EXCAVATOR CYCLE TIME				TOTAL CYCLE TIME	
	Dig Time (S)	Loading Time (S)	Waste Time (S)	Empty Play Time(S)	SECOND	MINUTE
1	22.08	14.18	7.49	16.23	59.98	1.00
2	23.04	14.02	7.16	15.68	59.91	1.00
3	22.14	14.53	7.16	16.05	59.87	1.00
4	22.49	14.61	7.51	15.37	59.96	1.00
5	22.20	14.64	7.30	15.80	59.94	1.00
6	22.49	14.13	6.97	16.39	59.98	1.00
7	22.44	14.35	6.83	16.34	59.96	1.00

Conditions in the field when data collection or collection is carried out:

Sunny weather

Soil Type: clay and sand

Bucket Capacity : 1.00 m3

b. Dump Truck Cycle Time

The data described below is data obtained by conducting observations of dump truck equipment every day. The implementation is intended to obtain the time of the dump truck cycle with units of seconds and is converted to units of minutes. The following is a recapitulation of the dump truck cycle time on the day1-7 are described through the scope of Table 4.1 below:

Table 2. Recapitulation of dump truck cycle time on days 1-7

No	DUMP TRUCK CYCLE TIME					TOTAL CYCLE TIME
	Load Time (m)	Transport Time (m)	Waste Time (S)	Return Time (m)	Loading Wait Time	MINUTE
1	3.09	48.26	28.47	33.43		114.29
2	3.07	47.95	29.03	34.47		114.29
3	3.07	47.98	28.86	34.39		114.29
4	3.03	48.22	28.77	34.20		114.22
5	3.07	48.00	28.68	34.43		114.24
6	3.06	48.08	28.74	34.18		114.25
7	3.05	48.01	28.85	33.98		114.15

Conditions in the field when data collection:

Sunny weather

Soil Type: clay and sand

Bucket Capacity : 20.40 m3

c. Heavy Equipment Productivity

1. Backhoe/Excavator Productivity Calculation

Calculation of backhoe productivity in units of m³/hour is carried out based on unobstructed conditions and is calculated for each working hour. The cycle time used is the average of the backhoe work cycle with a duration of seven days of research implementation, the formula used by the researcher is described below:

$$Q = \frac{60 \; x \; q \; x \; E}{Ct}$$

$$Q = \frac{60 \; x \; 1 \; x \; 0.68}{1}$$

Q = 40.8 m3/hour

So the backhoe productivity on the Jakarta MRT station construction project CP 203 phase 2A is 40.8 m3/hour.

2. Excavator/backhoe Standard Productivity Calculation

Calculation of excavator productivity is carried out using the formula described below:

$$Q = \frac{V \; x \; Fb \; x \; Fa \; x \; 60}{Ts \; x \; Fv}$$

$$Q = \frac{1{,}00 \; x \; 0{,}85 \; x \; 0{,}80 \; x \; 60}{0{,}89 \; x \; 1}$$

Q = 45.8 m3/hour

SoThe standard productivity of excavators on the Jakarta MRT station construction project CP 203 Phase 2A is45.8 m3/hour

Table 3. Bucket Factor"PUPR Regulation No. 8 of 2023"

Operating Conditions	Field conditions	Factor
Easy	Ordinary soil, loam, soft soil.	1.1 – 1.2
Currently	The soil is usually sandy, dry.	1.0 – 1.1
It's a bit difficult	The ground is usually rocky.	0.9 – 1.0
Difficult	Crushed stone results	0.8 – 0.9

Table 4. Mining conversion factor"PUPR Regulation No. 8 of 2023"

Excavation conditions (excavation depth / maximum excavation depth)	Condition of throwing away, spilling (dumping)			
	Easy	Normal	A bit 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	

Table 5. Excavator work efficiency factor "PUPR Regulation No. 8 of 2023"

Operating Conditions	Efficiency Factor

Good	0.83
Currently	0.75
A little less	0.67
Not enough	0.58

3. Dump Truck Productivity Calculation

This calculation is carried out with units of m^3/hour, the same as for backhoes, carried out in unobstructed conditions and calculated for each operational hour. The cycle time (Ct) used is the average time that is originally from the dump truck cycle with a duration of seven days of observation,The researcher explains the formula below:

$$Q = \frac{60 \; x \; q \; x \; E}{Ct}$$

$$Q = \frac{60 \; x \; 20.40 \; x \; 0,76}{114,29}$$

$$Q = 8.13 \text{ m3/hour}$$

So the productivity of the Dump Truck on the Jakarta MRT station construction project CP 203 phase 2A is 8.13 m3/hour.

4. Dump Truck Standard Productivity Calculation

To carry out the calculation of standard dump truck productivity, researchers use the formula described below:

$$Q = \frac{V \text{ x } Fa \text{ x } 60}{Ts \text{ x } D}$$

$$= \frac{20,40 \text{ x } 0,85 \text{ x } 60}{217 \text{ x } 1,50}$$

$$= 3.28 \text{ m3/jam}$$

So the standard productivity of dump trucks in the Jakarta MRT station project CP 203 Phase 2A is 3.28 m3/hour

Table 6. Dump truck efficiency factor "PUPR Regulation 8 2023"

Operating Conditions	Efficiency Factor
Good	0.83
Currently	0.80
A little less	0.75
Not enough	0.70

Table 7. Dump truck bucket factor (PUPR Regulation 8 2023)

Fill Level	Bucket Factor (Fb)
Very Full	1.0 – 1.1
Normal	0.9 – 1.0
Not Full	0.7 – 0.9

Table 8. Dump truck speed "PUPR Regulation 8 2023"

Field conditions	Load conditions	Speed, v, km/h
Flat	Contents	40
	Empty	60
Uphill	Contents	20
	Empty	40
Decrease	Contents	20
	Empty	40

5. Calculation of Working Hours

To carry out the calculation of the length of time of work done by the tool thanks to using the formula. The formula is described below:

$$t = \frac{\text{Total}}{Qdt}$$

$$t = \frac{22{,}043}{8.13 \text{ m3 / hour}}$$

t = 2,422 hours

t = 133 days

t = 3.77 (3 months 23 days)

Table 9. Data recapitulation - calculation data

HEAVY EQUIPMENT	ACTUAL PRODUCTIVITY	THEORETICAL PRODUCTIVITY	EFFICIENCY
Excavator	40.8 m3 /Hour	45.8 m3/Hour	$\frac{40{,}8}{45{,}8}\ x\ 100 = 89\ \%$
Dump Truck	8.13 m3/Hour	3.28 m3 /Hour	$\frac{8{,}13}{3{,}28}\ x\ 100 = 247\ \%$

CONCLUSION

Based on the results of observations and analysis of heavy equipment productivity in construction excavation work, the following conclusions can be drawn:

1. The actual productivity of the excavator is 40.8 m3/hour compared to the theoretical productivity of 45.8 m3/hour, indicating a working efficiency of around 89%, reflecting optimal performance in the field.
2. The dump truck's actual productivity of 8.13 m3/hour far exceeds the theoretical productivity of 3.28 m3/hour, indicating high operational effectiveness, supported by good field conditions and time management.
3. The estimated completion time for excavation work based on actual productivity is approximately 3 months 23 days (±113 calendar days), while the project schedule sets a time of 105 calendar days (3 months 15 days), indicating a potential delay of approximately 8 days if referring to current productivity.
4. This difference in completion time is likely due to factors such as assumed working hours, implementation of shifts, parallel work execution, and different field efficiencies.
5. The combination of heavy equipment used, namely 1 excavator unit and 4 dump trucks, has supported the work effectively, but periodic evaluation and adjustments are needed to ensure that project targets are met.

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