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Optimizing the Use of Heavy Equipment on Earthworks on the Syamsudin Noor Banjarbaru Airport Ring Road

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ABSTRACT

Earthworks on the Syamsudin Noor Banjarbaru Airport Ring Road Construction Project in 2019 include activities of digging, moving, displacing, leveling, forming the road body and compacting embankment soil in a loose volume of 375,000.00 m3 in solid with laterite soil type (chosen fill) . The heavy equipment used will be calculated for productivity, tool requirements and operational costs for each tool, namely: Komatsu PC 200 Excavator, Nissan Hino FM 260 JD 16 m3 Dump Truck, Catterpillar D6R Bulldozer, Catterpillar 120 G Motor Grader and Vibratory Roller Bomag Komatsu BW 217 D. Analysis and calculations using data analysis methods include material analysis, work implementation methodology, equipment production calculations, tool requirements, and equipment operating costs to complete the work. The results of the analysis show that Excavator productivity is 150.70 m3/hour, number of 3 units, operational costs Rp. .77m3/hour, number of 2 units, operational costs Rp. 1,617,521,830.24, Motor Grader productivity 1,392 m3 / hour, quantity 1 unit, operational costs Rp. 247,830,796, 12 and Vibratory Roller productivity 241.07 m3 / hour, number of 2 units, operational costs Rp. 757. 806,142.93. with a total cost of using heavy equipment for earthworks of Rp. 8,481,158,634.27

INTRODUCTION

The development of infrastructure in Indonesia, including airports, buildings, roads, and bridges, is currently progressing very rapidly. Particularly, road construction, which serves as a crucial link between regions, contributes to the development of various sectors such as the economy, politics, social affairs, culture, and defence and security. Banjarbaru, the capital city of South Kalimantan Province and one of the gateways to the central part of Indonesia, plays a significant role in the economic development and tourism advancement in South Kalimantan Province.

To build infrastructure, heavy equipment is needed, which is known in the field of civil engineering as tools used to assist humans in carrying out construction work. Heavy equipment is a crucial factor in construction activities or infrastructure projects, especially large-scale construction projects. The purpose of using heavy equipment is to facilitate humans in carrying out their work so that the expected results can be achieved more easily in a relatively short period of time.

Productivity analysis is a method of calculation used to determine the output of each piece of heavy equipment. By considering the cycle time of heavy equipment, productivity can be determined for each piece of heavy equipment. Knowing the productivity of each piece of heavy equipment for earthwork or excavation tasks, such as excavators, bulldozers, motor graders, vibratory rollers, and dump trucks, is essential. This is done to achieve optimal work results with minimal costs.

Considering the description and explanation in the background, the author is impressed with the theme or topic of the transportation sector, especially concerning the calculation of specific heavy equipment productivity used as a substitute for manual labour to expedite work. As a result, the author is interested in conducting research under the title "Optimisation of Heavy Equipment Usage in the Earthwork of the Syamsudinor Airport Ring Road in Bangalore City."

METHODS

Data Collection Methods

The research method is the study object of a case to be adjusted with the most suitable sequence for the research object. In general, research starts with the stage of analysing data obtained directly. Corrections are made during the project's lifespan using daily, weekly, and monthly data recorded in daily reports that can calculate the productivity figures of work tools. The methods in this research are literature reviews, which are a way to obtain data by conducting literature research. Field study, conducting observations in the field. Equipment Study: understanding the workings of heavy equipment. Collection of primary data. Data analysis and processing, which involves analysing the collected data and then processing it to obtain the desired results, Presenting the analysis results and drawing conclusions. The project location is in Landasan Ulin Subdistrict, Banjarbaru City, South Kalimantan Province.

Soil Data

The types of soil found around Syamsudin Noor Airport, Banjarbaru, include ordinary fill soil and selected fill soil. Quality assurance is conducted by CBR (California Bearing Ratio) tests, meeting the requirements of the General Specifications of Bina Marga 2018 revision 2. The soil is then transported by dump trucks in a loose condition and compacted using heavy equipment. The estimated volume of soil to be filled is 300,000 m^3. The duration of the earthwork operation is 110 calendar days. The volume of clay soil or selected fill.

Excavation Equipment

In earthwork operations, excavation of material or soil is done using an excavator to extract the earth and then transfer it to dump trucks. To calculate the production quantity per hour of the excavator, it must be continuously monitored with equipment data, which includes the equipment type (excavator), the brand used (Komatsu PC 200), the equipment year (2014), the bucket capacity (1.5 m^3), and the engine power (140 HP).

Transportation Equipment

The fill material/soil is transported by dump trucks to the work site with an average distance of 18.0 km. The spreading of material/soil dumped by dump trucks from the quarry to the work site (project) is undertaken. To calculate the production quantity per hour, dump trucks must work continuously with equipment data including equipment type (Dump Truck), brand used (Hino FM 260 JD), equipment year (2014), capacity of 16.0 m^3 (9-10 tons), and engine power of 320 HP.

Spreader Equipment

The spreading of material and soil dumped by dump trucks at the project site is done using a bulldozer. To calculate the production quantity per hour, the bulldozer must work continuously with equipment data including equipment type (Bulldozer), brand used (Caterpillar D6R), equipment year (2014), blade size (H: 1.2 m, L: 2.4 m), and engine power of 165 HP.

Slope Maker Equipment

To level the road and create road slopes according to the working drawings, a motor grader is used. To calculate the production quantity per hour, the motor grader must work continuously with equipment data, including equipment type (Motor Grader), brand (Caterpillar), equipment model (120 G), equipment year (2014), and blade size (H: 0.654 m, L: 3.710 m).

Compaction Equipment

To compact the embankment soil on the roadbed after shaping it according to the working drawings, along with a slope matching the maximum planned slope of 3%, compaction is carried out using compaction equipment. In this project, a vibratory roller is used.

RESULTS AND DISCUSSION

Located in Landasan Ulin District, Banjarbaru City, South Kalimantan Province.

Ficture 1. Existing Condition of the Project Site

The time required to carry out research is around 12 (twelve weeks) or approximately 3 months.

Project Work Data

This data analysis aims to obtain information about the efficiency of the equipment used in the road construction process. These data are:

1. Volume of embankment (solid) = 300,000 M3.
2. Quarry distance to work location = 12 Km.
3. Effective working time per day = (8 normal hours – 1 hour rest) = 7 hours
4. Land Convertion Factor = (original soil contidion = 1.00, loose condition= 1.25 solid condition = 0.9).
5. Project Impelementation Time = 110 days.

Digging Tools

- Brand= Komatsu
- Type= PC 200
- Year= 2014
- Bucket volume= 1.5 m^3
- Equipment condition= Good
- Bucket factor= 80%
- Work Efficiency= 0.75

Table 1. PC 200 Excavator Cycle Time (CMS) Project Implementation Time

Cycle	Observation				
	Time (Seconds)				
	Dig	Play (fill)	Throw away	Spin(blank)	Total
1	5	7	5	5.5	22.5
2	5	6	4	5	19.5
3	5	6	5	6	22
Average	5	6.33	4.67	5.5	21.5

Calculation

a) Excavation volume

Because of Clay, so the volume times 1.25

V = 300,000 x 1.25 = 375,000 m^3

b) Effective productivity per hour

$$\frac{Excavation\ Volume}{total\ working\ hours\ x\ tool\ working\ hours} = \frac{375.00}{110\ x\ 7} = 487.03\ m3/hour$$

c) Excavator Productivity

$$Q = \frac{1.2\ x3600\ x0{,}75}{21.5} = 150.70\ m3\ /\ hour$$

d) Time available for excavation work

Tool working days x tool working hours = 110 x 7 = 770 tool working hours

e) Excavator needed

$$\frac{effective\ productivity}{productivity\ of\ available\ time} = \frac{487.03}{150.70} = 3.235\ units \approx 3.0\ units$$

f) Excavator working hours required

$$= \frac{volume\ of\ soil\ excavation}{hourly\ productivity\ x\ number\ of\ tools}$$

$$= \frac{375{,}000}{150.70\ x\ 3} = 829.46\ hours$$

g) Site Output per day

=Number of tools x hourly productivity x working hours

= 3 x 150.7 x 7 = 3164.7 m3 / day

Equipment for transporting / moving embankment / embankment

Table 2. Hino FM 260 JD Dump Truck Cycle Time

Observation					
Location	Time (minutes)				
	Loading time	TimeTransport: 20 km/hour)	Time unloading and loading	Timereturn :35 km/h)	Time loading position
Quarries	3,057	36	3	20.40	1

a) Load Time = 3.057 minutes
b) Transport Time
Average speed of content (V1) = 20 Km/hour
Transport time = 36 minutes
c) Return Time
Average empty speed (V2) = Km/h
Average speed = 20.40 minutes
d) Loading and unloading time = 3 minutes
e) Dump truck time to take loading position = 1 minute
f) Dump Truck cycle time (Cmt) = 3.057 + 36 + 20.40 + 3 +1 = 63.457 minutes = 1.058 Hours
g) Production per cycle = q = q1 x K = 16 x 0.80 = 12.8 m^3
h) Total rit Dump Truck

$$= \frac{Working\ hours}{Cmt} = \frac{7}{1.057} = 6{,}622\ rit = 7\ rit$$

i) Productivity of 1 (one) Dump Truck per hour

$$Q = \frac{q\ x\ 60\ x\ Et}{Cmt} = x\ number\ of\ rites$$

$$= \frac{12{,}8\ x\ 60\ x\ 0.75}{63{,}457}\ x\ 7 = 62.69\ m3\ /\ hour$$

j) Production of 1 (one) Dump Truck per day = dump truck production per hour x working hours = 62.69 x 7 = 438.84 m^3
k) Number of Dump Trucks required

$$= \frac{Excavator\ daily\ site\ output}{Product\ dump\ Truck\ per\ hour} = \frac{3164.70}{438.84} = 7{,}211 \approx 8\ Dump\ Truck$$

l) Required working hours of Dump Truck

$$= \frac{volume\ of\ excavated/fill\ soil}{Amount\ DT\ x\ DT\ productivity} = \frac{375{,}000}{8\ x\ 62.69} = 747.73\ Hours$$

Spreading Tool

Table 3. Caterpillar D6R Bulldozer Cycle Time

Observation			
Time (minutes)			
Average speed		Displacement distance (m)	Change time gear (minutes)
Forward (F)	Backward (R)		
5 Km/h	8km/h	25	0.1

a) Production per cycle = 2.4 x (1.2)2 x 0.8 = 2.764
b) Cycle time (Cm)
Forward speed (F) = 5 km / h = 83.33 m / min
Reverse speed (R) = 8 km / h = 133.33 m / min
Gear change time (Z) = 0.1 min

c) Bulldozer productivity

$$Q = \frac{q \times 60 \times 0.75}{0.587} = 211.77\ m3 / hour$$

d) Bulldozer production per day = 211.77 x 7 = 2541.26 m3 / day

e) Number of Bulldozers required

$$= \frac{Site\ out\ Excavator}{daily\ bulldozer\ production} = \frac{3164.7}{2541.26} == 1.245 \approx 2$$

f) Amount O'clock work which required bulldozer

$$= \frac{volume\ of\ excavated\ soil}{number\ of\ tools\ x\ production\ per\ hour} = 885{,}69\ jam$$

Compactor / Compactor Tool

a) Production per cycle

$$Q = \frac{V \times 1000 \times W \times E \times t}{N} = \frac{5 \times 1000 \times 1.5 \times 0.75 \times 0.30}{7}$$

b) Daily productivity = 241.07 x 7 = 1687.49 m3 / day

c) Number of Vibro Rollers required

$$= \frac{site\ excavator\ output\ per\ day}{Products\ Per\ Day} = \frac{4200}{1687.49} = 2{,}489\ Units \approx 2$$

d) Time required by Vibro Roller

$$= \frac{volume\ of\ embankment\ soil}{Number\ of\ tools\ x\ productivity\ per\ hour} = \frac{375{,}000}{2 \times 241.07} = 777.78\ hours$$

Equipment Cost Analysis

Equipment costs are carried out using the Work Unit Price Analysis method (AHP) Bina Marga in 2019or Owner Estimate. From the results of the analysis and calculation of the equipment, the operational unit price of the equipment per operational hour is: Excavators Rp.788,437.79, Dump Truck Rp. 651,817.34- Bulldozer Rp. 913,142.20, Motor Grader Rp. 919,936.14 and Vibratory Roller Rp. 487,159.70.

Table 4. Recapitulation of Budget Costs for Heavy Equipment Requirements'

Tool's name	AmountTools (Units)	Tool Working Hours (Hours)	Cost Equipment Operation / Hours	Total Price (Rp)
Excavators	3	829.46	788,437.79	1,961,932,827.88
Dump Truck	8	747.73	651,817.34	3,899,067,037.11
Bulldozer	2	885.69	913,142.20	1,617,521,830.24
MotorcycleGrader	1	269.40	919,936.14	247,830,796.12
Vibratory Rollers	2	777.78	487,159.70	757,806,142.93
Total	-	-	-	***8,484,158,634.27***

CONCLUSION

Based on analysis & calculations of the use of heavy equipment for earthworks on the Syamsudin Noor Airport Ring Road Construction project withvolume of selected embankment/fill in loose condition: 375,00.00 m3, road width 24.0 m, length 5,495 m with heavy equipment, the following conclusions can be drawn: Productivity of 1 (one) Komatsu PC 200 Excavator: 150.70 m3/hour, quantity required: 3 units with cost: Rp. 1,961,932,827.88 productivity of 1 (one) Hino FM 260 JD Dump Truck: 62.69 m3 / hour, quantity: 8 units, with cost: Rp. 3,899,067,037, 11 productivity of 1 (one) unit of Caterpillar D6R Bulldozer: 211.77 m3 / hour, quantity: 2 units with cost: Rp. 1,617,521,830.24, productivity of 1 (one) Catepillar Motor Grader unit: 1,392 m3 / hour, total : 1 unit at a cost of Rp. 247,830,796.12 and productivity of 1 (one) Bomag Komatsu Vibratory Roller: 241.07 m3 / hour, quantity: 2 units at a cost of Rp. 757 806 242.93.

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