Estimated Cost And Productivity Of Heavy Equipment Dump Truck On The Blitar / Malang Sp 5 Purwodadi Sta 8 + 450 – 8 + 500 Bts Road Project

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Abstract
Developments in areas such as roads, buildings, bridges, canals, and other developments are currently developing in the Purwodadi area. One of the jobs, namely the excavation process with a large scale of work, needs to be taken into account in terms of time, cost, and selection of equipment types. During the project, the costs incurred must also be taken into account. This is necessary to complete the work more easily, quickly, and efficiently. Dump trucks are medium to long-distance material transport vehicles. This research aims to determine the dump truck's productivity, the work's budget, and the time required to complete the regular excavation work for STA 8+450 – 8+500 on the BTS BLITAR/MALANG SP 5 PURWODADI road construction project. The research method used is a survey and observation method during the project and calculating the estimated Budget Plan for the rental of heavy equipment Dump Trucks. The results obtained are the number of heavy equipment used in carrying out ordinary excavations and embankments is two units of Dump Trucks with a capacity of 4 m³ with each productivity of 52 m³/hour, which requires 617 cycles to transport material from the excavation area to the stockpile area. Based on the analysis, the estimated cost for the heavy equipment budget for dump trucks is Rp. 5,610,000,00 (Five Million Six Hundred and Ten Thousand Rupiah).

Keywords: Dump Truck, Estimation, Productivity

INTRODUCTION
Developments in areas such as roads, buildings, bridges, canals and other developments are currently developing in the Purwodadi area. In order to support the plan to create an education and housing center area, new layouts or new alternatives, such as building access roads (Nugraha et al., 2017).

In one of the jobs, namely the excavation work process with a large scale of work, it is necessary to take into account terms of time, cost, selection of the type of equipment, and the number of mechanical equipment needed according to the type of work being carried out. This is necessary to complete the work more easily, quickly, and efficiently. Construction project work on a small or large scale of ways requires heavy equipment which is the main instrument to facilitate a job.

In general, the factory produces the heavy equipment used in the project according to the function of each heavy equipment such as drum trucks, excavators, loaders, transporters, spreaders, etc. The use of heavy equipment is very important in the process of accelerating the implementation of construction project work by redetermined targets (Kalengkongan et al., 2020).

Determining the number of heavy equipment also has a major impact on the smoothness and timeliness of carrying out work because determining the number of heavy equipment will definitely have an impact on how quickly a job is completed. Heavy equipment is said to be productive if the equipment used rotates continuously in accordance with the cycle without stopping during working hours.

Cost planning is also needed in a job. The purpose of making a budget plan is to know the unit price of each job that is used as a guide in spending costs at the time of execution of the work. Cost-effectiveness and efficiency are important factors for success in carrying out a job (Effendi et al., n.d.)

In the project construction of the BTS BLITAR/MALANG SP 5 PURWODADI road, one of the heavy equipment used is a Dump Truck. Dump truck is a medium to long-distance material transport vehicle (Rasma & Basri, 2019). Based on the demolition method there are 3 kinds of Dump Trucks, namely: Side Dump...
Trucks (shedding towards the side), Rear Dump Trucks (spilling towards the back), Rear and Side Dump Trucks (spilling towards the back and towards the side) (Zulkarnain, 2020).

During the project, the costs that must be incurred must be considered. The calculation of the unit price of work must be adjusted to the specifications used, technical assumptions that support the analysis, for the use of mechanical tools, or manually, in accordance with the applicable provisions and conditions, and because it only considers local technical considerations from the location and soil conditions (Andeva et al., 2018).

Therefore, the accuracy of the selection of heavy equipment must be considered so that the work can be carried out smoothly. This study has a purpose, namely to determine the productivity of the dump truck, the budget for the work and the time required to complete the usual excavation work for STA 8+450 – 8+500 on the BTS BLITAR/MALANG SP 5 PURWODADI road construction project. It is expected that the results to be obtained are knowing the number of dump truck heavy equipment, the cost budget and the time required.

**RESEARCH METHODS**

The research method is a technique used by a researcher to achieve the goal of finding the answer to a problem. In this study, the object specified is the BTS BLITAR/MALANG SP 5 PURWODADI road construction project which refers to earthworks. The data used are primary and secondary data. Data collection is done by observation, interviews and literature study.

Several stages will be carried out in this research, namely surveys and observations during the project and the calculation of the estimated Budget Plan for Dump Truck heavy equipment rental. Researchers conducted a cost comparison analysis on costs based on contracts and costs based on HSP. The type of dump truck used is a dump truck with a capacity of 4 m³. The cost of excavation work & heavy equipment in the project contract is Rp. 5,610,000.00 with a volume of 2,468,695 m³ of soil excavation.

### Table 1. Excavation Volume Data

<table>
<thead>
<tr>
<th>Component</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>a. STA 8 + 450 (Left)</td>
<td>11.03</td>
</tr>
<tr>
<td>b. STA 8 + 500 (Left)</td>
<td>34.07</td>
</tr>
<tr>
<td>c. Jarak STA</td>
<td>50</td>
</tr>
<tr>
<td>Total Volume ((a+b)/2*c)</td>
<td>1,127.63 m³</td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>a. STA 8 + 450 (right)</td>
<td>19.63</td>
</tr>
<tr>
<td>b. STA 8 + 500 (right)</td>
<td>34.01</td>
</tr>
<tr>
<td>c. STA distance</td>
<td>50</td>
</tr>
<tr>
<td>Total Volume ((a+b)/2*c)</td>
<td>1,341.07 m³</td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Total Excavation Volume (A + B)</td>
<td>2,468,695 m³</td>
</tr>
</tbody>
</table>

Source: Author’s Preparation

**A. Dump Truck Heavy Equipment Productivity**

Calculation productivity The tool aims to determine the production capacity of heavy equipment per unit time, the number of heavy equipment needed, and the length of time it takes to complete the job (Hadihardaja, 1998). With this goal, the results to be achieved are knowing the number of heavy equipment, budget and time required to complete the job (Purwanto et al., 2016). The following is the formula for the productivity of heavy equipment:

\[
LT = \frac{cd}{q1} \times k \times cm
\]

Figure 2. Dump Truck 4m³
(Source: Author’s documentation)

Dump Truck the one used for this project is a dump truck 4 m³ capacity. Productivity dump trucks depending on the work cycle of the construction project. The following is the calculation of dump truck productivity:

1. Loading time

\[
LT = \frac{cd}{q1} \times k \times cm
\]
2. Transport time (hauling time)
   \[ HT = \frac{D}{V_1} \]  

3. Return time
   \[ RT = \frac{D}{V_2} \]  

4. Dump truck cycle (Cycle time truck)
   \[ cmt = \text{loading time} + \text{hauling time} + \text{unloading time} + \text{time Back} + \text{Waiting time} \]  

5. Production per cycle
   \[ c = qxk \]  

6. Dump truck productivity
   \[ P = \frac{c \times 60 \times E}{cmt} \]  

Information:
- P: Productivity per hour (m³ hours)
- LT: loading time (minutes)
- HT: Hauling time (minutes)
- RT: Return time (minutes)
- CD: Dump truck volume (m³)
- ql: Excavator bucket capacity (m³)
- q: Dump truck capacity (m³)
- k: Factor bucket
- cm: Excavator cycle time (minutes)
- D: Transport distance dump trucks (m)
- V1: Average speed loaded truck (m/min)
- V2: Average speed empty truck (m/min)
- cmt: Cycle time truck/cycle time dump trucks (cmt)
- c: production per cycle
- E: work efficiency

**Unit price of work = Unit price of tools x**  

After getting the value of the unit price of work and the volume of work then calculate the cost budget plan with the calculation formula:

\[ \text{RAB} = \sum \text{(Volume x Unit Price)} \]  

**RESULTS AND DISCUSSIONS**

**A. Productivity Calculation Results for Dump Trucks in Ordinary Excavation Areas**

In this study, dump trucks are used for loading equipment from ordinary excavations STA 8+450 – 8+500 to the stockpile area of 8+350 – 8+400. The following is a productivity calculation for dump truck heavy equipment:

- Assumption
  - Dump truck capacity (q): 4m³ (Picture 3)

![Figure 3. Dump truck dimensions](image)

- Working hours per day: 8 hours
- Transport distance (D): 100 m
- Work efficiency (E): 0.83 (Table 1)

<table>
<thead>
<tr>
<th>Tool Operating Conditions</th>
<th>Machine Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Good</td>
<td>Good</td>
</tr>
<tr>
<td>Very Good</td>
<td>0.83</td>
</tr>
<tr>
<td>Good</td>
<td>0.78</td>
</tr>
<tr>
<td>Normal</td>
<td>0.72</td>
</tr>
<tr>
<td>Bad</td>
<td>0.63</td>
</tr>
<tr>
<td>Very Bad</td>
<td>0.52</td>
</tr>
</tbody>
</table>

*Source: Hadihardaja, dkk (1998)*

- Fill speed (V1): 20 km/hours
- Empty speed (V2) : 40 km/hours
- Distance (D) : 100 meters
- Factor bucket (k) : 0.8 (Table 2)

Table 3. Factor bucket excavator

<table>
<thead>
<tr>
<th>Loading Conditions</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>1.0 - 0.0</td>
</tr>
<tr>
<td>Medium</td>
<td>0.8 - 0.6</td>
</tr>
<tr>
<td>Very Difficult</td>
<td>0.6 - 0.5</td>
</tr>
<tr>
<td>Difficult</td>
<td>0.5 - 0.4</td>
</tr>
</tbody>
</table>

Source: Hadihardaja, dkk (1998)

- Cycle time excavator (cm) : 24 seconds
- Dump truck volume (cd) : 4 m³

b. Loading time (LT)

Loading time for a dump truck is the length of time it takes for a dump truck to load material by an excavator, here is how long it takes to load a dump truck:

\[
LT = \frac{cd}{aq} \times k \times cm
\]

\[
= \frac{4}{0.92} \times 0.8 \times 24
\]

\[
= 83,4782 \text{ seconds}
\]

\[
= 1.39 \text{ minutes}
\]

c. Transport time (HT)

Dump truck transportation time is the length of time it takes the dump truck to travel with a load. Following are the transportation times:

\[
HT = \frac{D}{v_1}
\]

\[
= \frac{100}{333.33}
\]

\[
= 0.30 \text{ minutes}
\]

d. Waste time (DT)

Dump truck dumping time or unloading time is the length of time it takes a dump truck to unload or unload materials:

\[
DT = 1 \text{ minute}
\]

e. Return time (RT)

Time dump truck return is the length of time it takes the dump truck on its way back unloaded (empty). Here's how long the dump truck returns:

\[
RT = \frac{D}{v_2}
\]

\[
= \frac{100}{666.66}
\]

\[
= 0.15 \text{ minutes}
\]

f. Waiting time

The dump truck waiting time is the time the dump truck is waiting to be loaded by the excavator:

\[
= 1 \text{ minute}
\]

g. Dump truck cycle (cmt)

Calculation of cycle time is defined as the full time the dump truck is working from the time of digging and loading, transportation time, loading time, return time, waiting time:
cmt = loading time + hauling time +
unloading time + time Back +
Waiting time
= 1.39 + 0.30 + 1 + 0.15 + 1
= 3.84 minutes

h. Production per cycle (c)
Production dump truck cycle is the production in
one cycle (round) the dump truck can transport
how many m$^3$ of soil material. The following is
the production per cycle of the dump truck:

\[ N = \frac{c_1}{(q_1 x k)} \]
\[ = \frac{4}{0.92 x 0.8} \]
\[ = 5.4 \text{ times} \]

\[ C = n x q_1 x k \]
\[ = 5.4 x 0.92 x 0.8 \]
\[ = 4 \text{ m}^3 \]

i. Dump truck productivity
Production capacity per hour or dump truck
productivity per hour is the sum of the dump
trick's ability to transport materials within one
hour with the production formula per cycle
multiplied by 60 minutes (1 hour) multiplied by
work efficiency divided by how many minutes of
dump truck cycle time in one round. The
following is the productivity of the dump truck:

\[ P = \frac{c x 60 x E}{cmt} \]
\[ = \frac{4 x 60 x 0.83}{3.84} \]
\[ = 52 \text{ m}^3/\text{hour} \]

j. Production of dump trucks per day
Production capacity per day is the sum of the
dump trucks' ability to transport soil material
within one working day with the hourly
production formula multiplied by the working
hours in a day:

= Dump truck production/hour x
working hours per day
= 52 x 8
= 416 m$^3$/day

k. Number of dump trucks needed
In completing the work of transporting material
from the usual excavation area to the stockpile
area, it takes how many dump trucks to complete
the work within 4 days. It can be seen by using the
site output excavator formula divided by dump
truck production in a day:

\[ \frac{\text{Produksi dump truck per hari}}{\text{Produkasi excavator}} \]
\[ = \frac{736}{416} \]
\[ = 1.8 \]
\[ = 2 \text{ units of dump trucks} \]

l. Total number of cycles
The total number of cycles is samamountow many
times the dump truck goes back and forth in
completing the work of transporting all excavated
materials to the landfill site. The total number of
dump truck cycles can be determined using the
formula for the volume of excavation divided by
production per cycle of the dump truck:

\[ \frac{\text{excavated volume}}{\text{Production per cycle}} \]
\[ = \frac{2468.695 \text{ m}^3}{4 \text{ m}^3} \]
\[ = 617 \text{ cycle times} \]

m. Coefficient
Coefficient heavy equipment is used as a
reference for calculating the cost
budget plan. The
following is the coefficient of dump truck heavy
equipment:

\[ \frac{1}{P} \]
\[ = \frac{1}{52 \text{ m}^3} \]
\[ = 0.02 \]

B. Calculation of Work Unit Price Analysis
Calculation of the unit price of excavator
equipment work based on the contract price:
Equipment price = Estimated Quantity x
Total cost of equipment rental
\[ = 0.0108 x 191.179.45 \]
\[ = 2.064.73 \]

Unit price of work = overhead & profit (10
% x equipment price) +
Equipment price
\[ = 206.47 + 2.064.73 \]
\[ = 2271.20 \]
Table 4. Dump Truck Equipment Rental Price Calculation

<table>
<thead>
<tr>
<th>No.</th>
<th>DESCRIPTION</th>
<th>CODE</th>
<th>COEFFICIENT</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>EQUIPMENT DESCRIPTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Equipment Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Power</td>
<td>Pw</td>
<td>123</td>
<td>Hp</td>
</tr>
<tr>
<td>3</td>
<td>Capacity</td>
<td>Cp</td>
<td>8</td>
<td>Ton</td>
</tr>
<tr>
<td>4</td>
<td>New tools</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. economical life</td>
<td>A</td>
<td>5</td>
<td>Year</td>
</tr>
<tr>
<td></td>
<td>b. working hours in 1 year</td>
<td>W</td>
<td>2,000</td>
<td>Hour</td>
</tr>
<tr>
<td></td>
<td>c. tool price</td>
<td>B</td>
<td>Rp 423.500.000.00</td>
<td>Rupiah</td>
</tr>
<tr>
<td>B</td>
<td>EXACT COST PER HOUR OF WORK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Tool Time Value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>= 10% x B</td>
<td>Cm</td>
<td>Rp 42,350.000.00</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Capital Installation Factors</td>
<td>= 1 x (1 +i)^A</td>
<td>D</td>
<td>0,11</td>
</tr>
<tr>
<td></td>
<td>(1 + i)^A-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Exact Cost Per Hour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Cost of Return on Capital</td>
<td>= (B - C) x D</td>
<td>E</td>
<td>Rp 20.963,25</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Assumptions, etc.</td>
<td>= 0,002 x B</td>
<td>F</td>
<td>Rp 423,50</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>OPERATING COSTS PER WORKING HOUR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Fuel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>= 0.127 Lt/hp/hour x Pw x Ms</td>
<td>H</td>
<td>Rp 87.637,50</td>
<td>Rupiah</td>
</tr>
<tr>
<td>2</td>
<td>Lubricant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>= 0.0125 Ltr/hp/hour x Pw</td>
<td>I</td>
<td>Rp 56.567,70</td>
<td>Rupiah</td>
</tr>
<tr>
<td>3</td>
<td>Maintenance and Repair</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>= (0.05 x - 13,7K x B) / 17,5%</td>
<td>K</td>
<td>Rp 10.587,50</td>
<td>Rupiah</td>
</tr>
<tr>
<td>4</td>
<td>Operator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>= 1 person/h x 1ml</td>
<td>L</td>
<td>Rp 15.000,00</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>TOTAL COST OF EQUIPMENT RENTAL-HOUR = (G + P)</td>
<td></td>
<td>S</td>
<td>Rp 191.179,45</td>
</tr>
<tr>
<td>E</td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Interest Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Operator / Driver Wages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Gasoline Fuel</td>
<td>Mb</td>
<td>Rp 7.650,00</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Diesel Fuel</td>
<td>Ms</td>
<td>Rp 8.700,00</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Lubricating Oil</td>
<td>Mp</td>
<td>Rp 45.990,00</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>VAT is taken into account on</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>the recapitulation sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Calculation of the Work Budget Plan

<table>
<thead>
<tr>
<th>No</th>
<th>Job Description</th>
<th>Volume</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Ordinary Excavation Work and Leveling in the Embankment Area</td>
<td>2.268,695</td>
<td>m3</td>
<td>2.271,20</td>
<td>5.606,900.08</td>
</tr>
<tr>
<td>TOTAL</td>
<td>COLLECTED</td>
<td>5.606,900.08</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Author’s Process

Based on the contract price from PT Moderna Teknik perkasa needed to carry out ordinary excavation work for STA 8+450 – 8+500 and leveling in the stockpile area of STA 8+350 – 8+400 is Rp.5,610,000.00 (Five Million Six Hundred Ten Thousand Rupiah).

CONCLUSIONS AND SUGGESTIONS

Based on the results of heavy equipment calculations on ordinary excavation work, BTS road projects Blitar / Malang sp 5 purwodadi sta 8+450 – 8+500, it can be concluded that the number of heavy equipment used in normal excavation and embankment is 2 Dump Trucks4 m3. Capacity with each productivity equal to 52 m3/hour which requires 617 cyclesto transport material from the excavated area to the stockpile area. The estimated cost required for the heavy equipment budget for dump trucks based on the analysis is Rp. 5,610,000.00 (Five Million Six Hundred and Ten Thousand Rupiah).

REFERENCES


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