CERUCUK
Volume 8 No. 7 2024 (327-336)

DETERMINING HEAVY EQUIPMENT FOR THE EXCAVATION AND STOCKPILING OF THE COAL HAULING ROAD DEVELOPMENT PROJECT

Sherina Srinajmi, Ir. Candra Yuliana, S.T., M.T.
Program Studi Teknik Sipil, Universitas Lambung Mangkurat
Jl. Jenderal Achmad Yani Km. 35,5 Banjarbaru, Kalimantan Selatan – 70714
e-mail: sherinasrinajmi8@gmail.com; candrayuliana@ulm.ac.id

ABSTRACT

The amount and time on the efficient operation of heavy equipment is the amount and duration resulting in low cost and targeted time. Thus, it is necessary to analyze the appropriate heavy equipment to achieve the most optimum alternative in terms of time and cost. This study used an analytical method involving collecting the data and calculating the productivity of heavy equipment used in constructions project. The researcher analyzed several alternatives for selecting the type of heavy equipment. Based on the results, it is shown that the amount of productivity of the tools that are used on the Excavation and Stockpiling of the Coal Hauling Road Development Project, the productivity value of the Excavator is 158,4 m3/h, Dump Truck is 180 m3/h, Bulldozer is 264,98 m3/h, Vibration Roller is 511,2 m3/h, and Motor Grader is 15660 m3/h. It can be concluded that determining the heavy equipment is recommended for the Excavation and Stockpiling of the Coal Hauling Road Development Project resulting in the alternative combination two that is included two units of Excavator, two units of Dump Truck, 1 unit of Bulldozer, 1 unit of Vibration Roller, and 1 unit Motor Grader. In contrast, alternative 2 had the most efficiency (optimum) in the amount of time and cost compared to alternatives 1 and 3.
Keywords: alternative, cost, determining, heavy equipment, optimum, productivity, time.

1. INTRODUCTION

A project can be regarded as a series of interconnected activities with a starting and ending point and is completed within a certain time and cost to achieve the agreed work results. The success of a project is determined by the suitability of time, cost, and quality specified in the contract documents. It is necessary to complete a project promptly at the lowest cost and produce a good quality result. In construction projects, project delays often occur, causing various losses for service providers and users. Therefore, human resources and heavy equipment used in the process are very influential on the time of project implementation. The amount and time of efficient operation of heavy equipment is the

amount and duration which can result in low cost and time according to the target. One of the problems related to the project implementation schedule, especially the use of heavy equipment with the amount of time and cost requirement, is needed to examine the issue related to this problem.

The productivity of heavy equipment is one of the determining factors for project implementation success. Good productivity creates the implementation of the project by a predetermined plan and vice versa. Considering that the cost of using heavy equipment to the total cost of a construction project is massive, it is necessary to plan for the use of heavy equipment that is precise and detailed to obtain the appropriate productivity and costs (Rochmanhadi, 1985). In the project examined in this study, there are several stages of work planned and implemented, one of which is earthworks. Earthworks include excavating, stockpiling, hauling, and compaction of the soil. Heavy equipment is used to make the work faster and better, such as Excavators, Dump Trucks, Bulldozers, Motor Graders, and Roller Vibrators. The heavy equipment used in the project must be to the situation and conditions so that the accuracy in selecting heavy equipment majorly affects the productivity of heavy equipment (Nunnally, 2007).

Therefore, several combinations of heavy equipment are needed to determine the productivity of these tools to determine which equipment has the optimum productivity in terms of time and cost. Thus, losses and delays in project execution can be minimized or even avoided. Regarding the previously explained problems, the main issues to be discussed in this study are: How to get the optimum combination of heavy equipment in terms of cost and time for earthworks on the Coal Haul Road Development project.

2. THEORETICAL STUDY

Construction projects involve interactions between the building elements, such as the owner, consultant, and contractor. Cooperation, coordination, and communication between the parties involved are significant to make the project successful because the project can be completed on time, costs do not exceed the budget, and the quality is as specified. Problems in project implementation will arise if the project objectives are not achieved. If this problem

is not managed properly, it will become a conflict. These conditions can affect work efficiency and productivity. In a construction project, many things can happen which can increase the duration or delay the completion of a project as a whole. Some of the most common causes include changes in field conditions, changes in design or specifications, weather changes, and unavailability of human resources and materials or equipment.

Based on the Regulation of the Minister of Public Works No. 11/PRT/M/2013 concerning Guidelines for Analysis of Unit Prices for Public Works, the actual production results of a piece of equipment used will not be the same as the calculation results based on capacity data written on the brochure, due to the many factors that affect the production process. The factors influencing the production process are operator, weather, field condition, and tool management. To make retrieving the values used easier, these factors are combined into one factor of general working conditions. Furthermore, these factors are utilized as a factor of tool work efficiency (Fa). Excavation and embankment work on this Haul Road Development project uses several types of heavy equipment, such as Excavators, Dump Trucks, Bulldozers, Motor Graders, and Roller Vibrators.

3. METHOD

The object of this study was the PT Tri Oetama Persada Transport Road Development Project which used existing data in the forms of equipment, equipment working hours, equipment rental costs, equipment specifications, and general project data. The data was collected by calculating the productivity of heavy equipment. There are two types of data: primary data (obtained from observation and interview) and secondary data (obtained from agencies related to research and previous studies of heavy equipment). Based on data analysis, it is expected to determine the efficiency of the combination of heavy equipment to obtain an efficient time and cost-efficient rental of heavy equipment on the construction of PT Triop Coal Hauling Road.

4. RESULT AND DISCUSSION

Stockpiling Implementation Method

The stockpiling is carried out in stages, such as excavation, stockpiling, and compaction. Excavation work has several operations that are: 1) Land Purging is carried out to get rid of all trees, obstructions, brush, trash, and other materials using an excavator that has two steps such as measurement survey work and land purging and stripping work; 2) Soil excavation work had some steps, such as determine the boundaries of the excavation area, with an average excavation depth of ± 5 to 10 meters, excavation of the soil is carried out using an excavator and transported by a dump truck. Fireplaces were carried out from the existing excavation using a bulldozer, and then, for leveling and shaping the road body utilized motor grader, which is compacted using a vibration roller, and checked whether the excavation results were by the elevation planned with the drawings. Subsequently, stockpiling and compaction work includes the procurement, transportation, spreading, and compaction of ordinary stockpiling according to the elevation and dimensions depicted on the drawings.

Calculation analyses were conducted in order to obtain an effective time and cost-efficient rental of heavy equipment on the construction, that is:

a. Calculation Analysis of Heavy Equipment Combination

1) Alternative 1

a) Excavator

Total item (n) = 1 unit

Landfill volume = 42.851 m^3

Excavator Production per hour (Q) = 79,2 m^3/hour

Excavator Production overall equipment = Q x n = 79,2 m^3/hour x 1 unit = 79,2 m^3/hour

Working time of Excavator = $\frac{\text{landfill volume}}{\text{excavator production}} = \frac{42.851}{79,2}$ = 541,048 ≈ 542 hour

Usage time of Excavator = 542 hour

Rent cost per hour = Rp. 580.000

Total rent cost = Rp. 580.000 x 542 hour x 1 unit = Rp. 314.360.000

b) Dump Truck

Volume to be transported = 42.851 m^3

Dump Truck Production per hour = 90 m^3/hour

Excavator Production = 79,2 m^3/hour

Total of Dump Truck (n) = $\frac{79,2}{90}$ = 0,88 ≈ 1 unit

Working time of Dump Truck = $\frac{42.851}{79,2}$ = 541,048 ≈ 542 hour

Rental cost per hour = Rp. 646.000

Total rent cost Dump Truck = Rp. 646.000 / hour x 542 x 1 unit = Rp. 350.132.000

c) Bulldozer

Bulldozer Production = 204,375 m^3/hour

Excavator Production = 79,2 m^3/hour

Total of Bulldozer (n) = $\frac{\text{excavator production}}{\text{bulldozer production}}$ = $\frac{79,2}{204,375}$ = 0,39 ≈ 1 unit

Working time of Bulldozer = $\frac{42.851}{79,2}$ = 541,048 ≈ 542 hour

Rental cost per hour = Rp. 550.000

Total rent cost of Bulldozer = Rp. 550.000 / hour x 542 x 1 unit= Rp. 298.100.000

d) Vibration Roller

Vibration Roller Production = 204 m^3/hour

Excavator Production = 79,2 m^3/hour

Total of Vibration Roller (n) = $\frac{\text{excavator production}}{\text{vibration roller production}}$ = $\frac{79,2}{204}$ = 0,39 ≈ 1 unit

Working time of Vibration Roller = $\frac{42.851}{79,2}$ = 541,048 ≈ 542 hour

Rental cost per hour = Rp. 410.000

Total rent cost of Vibration Roller = Rp. 410.000 / hour x 542 x 1 unit = Rp. 222.220.000

e) Motor Grader

Motor Grader Production = 8505 m^3/hour

Excavator Production = 79,2 m^3/hour

Total of Motor Grader (n) = $\frac{\text{excavator production}}{\text{,motor grader production}}$ = $\frac{79,2}{8505}$ = 0,01 ≈ 1 unit

Working time of Motor Grader = $\frac{42.851}{79,2}$ = 541,048 ≈ 542 hour

Rental cost per hour = Rp. 426.000

Total rent cost Motor Grader = Rp. 426.000 / hour x 542 hour x 1 unit = Rp. 230.892.000

2) Alternative 2

a) Excavator

Total items (n) = 2 unit

Landfill volume = 42.851 m^3

Excavator Production (Q) = 79,2 m^3/hour

Excavator Production overall equipment = Q x n = 79,2 m^3/hour x 2 unit = 158,4 m^3/hour

Working time of Excavator = $\frac{\text{landfill volume}}{\text{excavator production}} = \frac{42.851}{158,4}$ = 270,524 ≈ 271 hour

Usage time of Excavator = 271 hour

Rental cost per hour = Rp. 580.000

Total rent cost = Rp. 580.000 x 271 hour x 2 unit = Rp. 314.360.000

a. Dump Truck

Volume to be transported = 42.851 m^3

Dump Truck Production = 90 m^3/hour

Production Excavator = 158,4 m^3/hour

Total Dump Truck (n) = $\frac{\text{excavator production}}{\text{dump}-\text{truck production}} = \frac{158,4}{90}$ = 1,76 ≈ 2 unit

Working time of Dump Truck = $\frac{42.851}{158,4}$ = 270,524 ≈ 271 hour

Rental cost per hour = Rp. 646.000

Total rent cost Dump Truck = Rp. 646.000 x 271 x 2 unit = Rp. 350.132.000

c) Bulldozer

Production Bulldozer = 204,375 m^3/hour

Production *Excavator* = 158,4 m^3/hour

Total of *Bulldozer* (n) = $\frac{excavator\ production}{bulldozer\ production} = \frac{158,4}{204,375}$ = 0,78 ≈ 1 unit

Working time *Bulldozer* = $\frac{42.851}{158,4}$ = 270,524 ≈ 271 hour

Rental cost per hour = Rp. 550.000

Total rent cost *Bulldozer* = Rp. 550.000 x 271 hour x 1 unit = Rp. 149.050.000

d) *Vibration Roller*

Production *Vibration Roller* = 204 m^3/hour

Production *Excavator* = 158,4 m^3/hour

Total of *Vibration Roller* (n) = $\frac{excavator\ production}{vibration\ roller\ production} = \frac{158,4}{204}$ = 0,78 ≈ 1 unit

Working time of *Vibration Roller* = $\frac{42.851}{158,4}$ = 270,524 ≈ 271 hour

Rental cost per hour = Rp. 410.000

Total rent cost of *Vibration Roller* = Rp. 410.000 / hour x 271 x 1 unit = Rp. 111.110.000

e) *Motor Grader*

Production *Motor Grader* = 8505 m^3/hour

Production *Excavator* = 158,4 m^3/hour

Total of *Motor Grader* (n) = $\frac{excavator\ production}{,motor\ grader\ production} = \frac{158,4}{8505}$ = 0,019 ≈ 1 unit

Working time of *Motor Grader* = $\frac{42.851}{158,4}$ = 270,524 ≈ 271 hour

Rental cost per hour = Rp. 426.000

Total rent cost *Motor Grader* = Rp. 426.000 x 271 hour x 1 unit = Rp.115.446.000

b) Alternative 3

a. Excavator

Total items (n) = 3 unit

Landfill volume = 42.851 m^3

Production *Excavator* (Q) = 79,2 m^3/hour

Production *Excavator* all equipment = Q x n = 79,2 m^3/hour x 3 unit = 237,6 m^3/hour

Working time of *Excavator* = $\frac{landfill\ volume}{excavator\ production\ equipment} = \frac{42.851}{237,6}$ = 180,35 ≈ 181 hour

Usage time of *Excavator* = 181 hour

Rental cost per hour = Rp. 580.000

Total rent cost = Rp. 580.000 x 181 hour x 3 unit = Rp. 314.940.000

b) *Dump Truck*

Volume to be transported = 42.851 m^3

Production *Dump Truck* = 90 m^3/hour

Production *Excavator* = 237,6 m^3/hour

Total of *Dump Truck* (n) = $\frac{excavator\ production}{dump\ truck\ production} = \frac{237,6}{90}$ = 2,64 ≈ 3 unit

Working time *Dump Truck* = $\frac{42.851}{237,6}$ = 180,35 ≈ 181 hour

Rental cost per hour = Rp. 646.000

Total rent cost of *Dump Truck* = Rp. 646.000 x 181 hour x 3 unit = Rp. 350.778.000

c) *Bulldozer*

Production *Bulldozer* = 204,375 m^3/hour

Production *Excavator* = 237,6 m^3/hour

Total of *Bulldozer* (n) = $\frac{excavator\ production}{,bulldozer\ production}$ = $\frac{237,6}{204,375}$ = 1,163 ≈ 2 unit

Working time of *Bulldozer* = $\frac{42.851}{237,6}$ = 180,35 ≈ 181 hour

Rental cost per hour = Rp. 550.000

Total rent cost *Bulldozer* = Rp. 550.000 x 181 hour x 2 unit = Rp. 199.100.000

Discussion

Based on the calculation analysis above, this study discovered three alternatives:

a. Alternative 1

Equipment	Total	Duration (h)	Rental cost per hour (Rp)	Cost (Rp)
Excavator Komatsu PC 200	1	542	580.000	314.360.000
Dump Truck Scania P380	1	542	646.000	350.132.000
Bulldozer Komatsu D 65	1	542	550.000	298.100.000
Vibration Roller CAT CB54B	1	542	410.000	222.220.000
Motor Grader Caterpillar 120G	1	542	426.000	230.892.000
Total		2.710		1.415.704.000

This alternative has a total working duration of 2,710 hours at STA 40+000 – 38+000 and costs Rp. 1,415,704,000. Alternative 1 will be used as a comparison with other alternatives.

b. Alternative 2

Equipment	Total	Duration (h)	Rental cost per hour (Rp)	Cost (Rp)
Excavator Komatsu PC 200	2	271	580.000	314.360.000
Dump Truck Scania P380	2	271	646.000	350.132.000
Bulldozer Komatsu D 65	1	271	550.000	149.050.000
Vibration Roller CAT CB54B	1	271	410.000	111.110.000
Motor Grader Caterpillar 120G	1	271	426.000	115.446.000
Total		1.355		1.040.098.000

This alternative has a total working duration of 1,355 hours and costs Rp. 1,040,098,000. When compared to alternative 1, there will be a reduction in the working duration of the tool and a reduction in costs.

c. Alternative 3

Equipment	Total	Duration (h)	Rental cost per hour (Rp)	Cost (Rp)
Excavator Komatsu PC 200	3	181	580.000	314.940.000
Dump Truck Scania P380	3	181	646.000	350.778.000
Bulldozer Komatsu D 65	2	181	550.000	199.100.000
Vibration Roller CAT CB54B	2	181	410.000	148.420.000
Motor Grader Caterpillar 120G	1	181	426.000	77.106.000
Total		905		1.090.344.000

This alternative has a total working duration of 905 hours and requires a fee of Rp. 1,090,344,000. When compared to alternative 1, there will be a reduction in the working duration of the tool and a reduction in costs.

From the calculations of alternative 1, alternative 2, and alternative three it can be seen in, the recapitulation results of the comparison of heavy equipment in terms of cost and time in the form of a percent (%) can be seen in the table below, where the table compares alternative 2 to alternative 1 (2-1), alternative 3 to alternative 1 (3-1) and alternative 3 to alternative 2 (3-2).

	Alternative 1	**Alternative 2-1**	**Alternative 3-1**	**Alternative 3-2**
time (%)	0	- 0,5	- 0,67 %	- 0,34 %
time (jam)	0	-13,55	-18,05	-4,5
cost (%)	0	- 0,27 %	- 0,22 %	+ 0,04 %
cost (Rp)	0	-375.606.000	-325.360.000	+ 50.246.000

The table above shows that alternative two use two units of Excavator, two units of Dump Truck, 1 unit of Bulldozer, 1 unit of Vibration Roller, and 1 unit of Motor Grader. This alternative has the most efficient cost and time compared to alternative one and alternative 3, where alternative 3 has a faster duration. However, the cost is greater, and alternative 1 has a lower cost. However, the duration is quite long, so from this analysis, it can be determined that the most efficient alternative in terms of time and cost is alternative 2.

5. CONCLUSION

Based on the results and calculations of alternative heavy equipment comparisons, the conclusion obtained is that the combination of heavy equipment is recommended for the Excavation and Stockpiling of the Coal Hauling Road Development Project is a combination of alternative two which uses two units of Excavators, two units of Dump Trucks, 1 unit of Bulldozer, 1 unit of Vibration Roller, 1 unit of Motor Grader. Alternative 2 has the most efficient (optimum) difference in working time and costs compared to alternatives 1 and 3. In the analysis of alternative 2, the working duration of the tool is 1,355 hours with a total cost of Rp. 1,040,098,000.

REFERENCES

Rochmanhadi. *Kapasitas dan Produksi AlatAlat Berat*: Departemen Pekerjaan Umum Jakarta, 1983

Rochmanhadi. Alat-Alat Berat dan Penggunaannya: Departemen Pekerjaan Umum Jakarta, 1986

Rochmanhadi. Alat-Alat Berat dan Penggunaannya: Departemen Pekerjaan Umum Jakarta, 1982.

Nunnally. S. W. *Construction Methods and Management Ed.7:* PEARSON PRENTICE H, 2007