

**ANALYSIS OF PRODUCTIVITY AND COST OF HEAVY EQUIPMENT IN
GRADED PAVEMENT WORK ON THE SYAMSUDIN NOOR
INTERNATIONAL AIRPORT ACCESS ROAD CONSTRUCTION PROJECT**

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ABSTRACT

This study aims to analyze the productivity and costs of heavy equipment used in granular pavement work on the Syamsudin Noor International Airport access road construction project. The analysis focuses on evaluating the performance and cost-effectiveness of various types of equipment, including wheel loader, dump trucks, motor grade, water tanker truck and vibratory roller. Data were collected through field observations and contractor reports, which were then analyzed using productivity calculation methods and cost analysis techniques. The results show that proper equipment management and optimization significantly impact project efficiency and budget control. This research provides valuable insights for improving the planning and execution of similar infrastructure projects.

Keywords: productivity, heavy equipment, cost analysis, granular pavement, airport access road

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This study aims to analyze the productivity and cost of heavy equipment used in the graded pavement work on the Syamsudin Noor International Airport access road construction project. The analysis focused on evaluating the performance and cost effectiveness of various types of heavy equipment, including wheel loader, dump trucks, motor grader, water tanker truck and vibratory roller. Data were obtained through field observations and contractor reports, which were then analyzed using productivity calculation methods and cost analysis techniques. The results showed that proper management and optimization of heavy equipment had a significant impact on project efficiency and budget control. This research provides useful insights to improve the planning and execution of similar infrastructure projects.

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1. INTRODUCTION

Infrastructure development is one of the key factors in supporting a country's economic growth. Roads as part of transportation infrastructure have a vital role in improving connectivity between regions, accelerating the distribution of goods and services, and facilitating community mobility. One of the government's strategic projects is the construction of an access road to Syamsudin Noor International Airport, which aims to improve air transportation services in South Kalimantan.

Graded pavement work is one of the important elements in road construction because it functions as a base layer that provides structural support for traffic loads. The successful execution of this work relies heavily on the use of appropriate and efficient heavy equipment. Heavy equipment such as wheel loader, dump trucks, motor grader, water tanker truck and vibratory roller play a major role in ensuring the quality and productivity of graded pavement works.

However, the challenges of heavy equipment management cannot be ignored. Poorly planned heavy equipment utilization can lead to increased operational costs, decreased productivity, and project delays. Therefore, an in-depth analysis of heavy equipment productivity and costs is required to support the smooth and efficient construction of this access road project.

This research tries to answer this need by focusing on evaluating the productivity of heavy equipment in graded pavement work. By understanding the performance of heavy equipment, contractors can take strategic steps to optimize the use of heavy equipment, so that project costs can be reduced without reducing the quality of work.

In addition, heavy equipment costs are often a major component in construction project budgets. Therefore, proper cost analysis not only helps in making operational decisions, but also supports more accurate budget planning. This becomes important in the face of challenging project costs that often fluctuate due to external factors, such as fuel and spare parts prices. This research also seeks to provide an overview of the relationship between machine productivity and cost efficiency in construction work. By understanding this relationship, it is hoped that the research results can contribute to improving the efficiency of infrastructure project implementation in the future, particularly with regard to graded pavement works.

The research methods used included field data collection through direct observation and analysis of contractor reports. This data was then processed using a quantitative approach to evaluate machine productivity and analyze the operational costs involved.

Overall, this research aims to provide practical solutions for heavy equipment management in road construction projects. The results are expected to be a reference for contractors, consultants, and other stakeholders in improving the efficiency and effectiveness of infrastructure projects in Indonesia.

2. THEORETICAL FOUNDATION

The use of heavy equipment in construction work has a theoretical basis that is closely related to the concepts of productivity, efficiency and cost management. Machine productivity is defined as the ability of a machine to complete a certain volume of work in a certain time, which is influenced by factors such as machine capacity, terrain conditions, and operator skills. This productivity theory becomes the basis for measuring machine performance in meeting construction work targets.

In addition to productivity, cost analysis theory plays an important role in construction project management. Heavy equipment costs include fixed costs such as depreciation and insurance, and variable costs such as fuel, maintenance, and operator wages. According to the construction economics literature, effective cost management can be done by minimizing variable costs through the selection of heavy equipment that suits the needs of the project and optimizing its operations. In the context of graded pavement work, pavement theory explains that the granular layer functions as a traffic load distributor to the underlying layers. The quality of graded pavement work is greatly influenced by the density and homogeneity of the material resulting from the use of heavy equipment such as vibratory roller. Therefore, this theory emphasizes the importance of selecting heavy equipment that is able to meet the technical specifications of pavement work.

Another theoretical foundation is the project management theory, which highlights the importance of planning, organizing, and controlling in the execution of construction projects. The use of heavy equipment must be carefully planned to ensure a balance between productivity and operational costs. A good project management approach can help minimize the risk of delays and cost overruns, thus supporting the overall smoothness and success of the project.

3. METHODS

This study used a quantitative approach to analyze the productivity and cost of heavy equipment in graded pavement work. Primary data were collected through direct observation at the project site of Syamsudin Noor International Airport access road construction, including observation of heavy equipment activities such as wheel loader, dump trucks, motor grader, water tanker trucks and vibratory roller. In addition, secondary data were obtained from the contractor's technical report, including details of heavy equipment specifications, operational schedule, and operational costs incurred.

To calculate machine productivity, a calculation method based on the volume of work completed in a given unit of time (m^3/hour) is used. This calculation takes into account factors such as equipment capacity, work cycle, and operational efficiency. Meanwhile, the cost analysis was conducted by separating the fixed cost and variable cost components to determine the total cost of using heavy equipment during the project. This analysis uses reference to the Ministry of Public Works and Housing Regulation Number 8 of 2023

The results of the data analysis were then analyzed using quantitative descriptive methods to provide an overview of the relationship between productivity and heavy equipment costs. This approach aims to identify certain patterns that can be used as a basis for decision making in the management of heavy equipment in similar construction projects. The conclusion of this analysis is expected to make a practical contribution to improving the efficiency of infrastructure development projects.

4. RESULTS AND DISCUSSION

This study provides an in-depth analysis of the productivity and cost of heavy equipment used in graded pavement work on the Syamsudin Noor International Airport access road construction project. Data obtained from field observations show that the productivity of heavy equipment is influenced by a number of factors, such as terrain conditions, operator skills, and equipment efficiency. Wheel loader, dump trucks, motor grader, water tanker trucks and vibratory roller, as the main tools used, have interrelated roles in ensuring the smooth running of construction work.

The results of the productivity analysis show that the wheel loaders has an average productivity of 114,75 m³ per hour. Motor graders has an average productivity of 120,81 m³ per hour with a work efficiency rate of 85%. This level of productivity is influenced by bucket capacity and standardized work cycles. Meanwhile, the dump truck used to transport the material has an average productivity of 5,27 m³ per hour. The difference in productivity between the wheel loader and the dump truck indicates the potential for adjusting the number of tools to improve work alignment.

The vibratory rollers, which compacts the granular material, has an average productivity of 109,69 m³ per hour. This result is influenced by the working speed and number of passes required to achieve the optimum density level. Water tanker trucks has an average productivity of 65,43 m³ per hour. Field analysis also showed that undulating terrain conditions affected the efficiency of the vibratory rollers, requiring adjustments to the operational speed to achieve optimal results. From the table, it can be seen that the bid data is lower than the field data.

Tabel 1 Comparison of Production Capacity

No	Type of Equipment	Productivity		Description
		Supply Data	Field Data	
1	<i>Wheel Loader</i>	92,75 m ³ /hour	114,75 m ³ /hour	Offer < Field
2	<i>Dump Truck</i>	3,39 m ³ /hour	5,27 m ³ /hour	Offer < Field
3	<i>Motor Grader</i>	77,73 m ³ /hour	120,81 m ³ /hour	Offer < Field
4	<i>Vibratory Roller</i>	66,60 m ³ /hour	109,69 m ³ /hour	Offer < Field
5	<i>Water Tanker Truck</i>	64,29 m ³ /hour	69,43 m ³ /hour	Offer < Field
	Total	304,76 m ³ /hour	419,87 m ³ /hour	Offer < Field

These coefficients assist in planning and calculating the efficiency of the heavy equipment used, enabling the optimization of equipment usage and more accurate cost calculations in the execution of construction projects. This indicates that, during the bidding process, the estimated equipment coefficients tend to be higher than those recorded under actual field conditions.

Tabel 2 Comparison of Equipment Coefficients

No	Type of Equipment	Equipment coefficient		Description
		Supply Data	Field Data	
1	<i>Wheel Loader</i>	0,0108 hour /m ³	0,0087 hour /m ³	Offer < Field
2	<i>Dump Truck</i>	0,2947 hour /m ³	0,1899 hour /m ³	Offer < Field

No	Type of Equipment	Equipment coefficient		Description
		Supply Data	Field Data	
3	<i>Motor Grader</i>	0,0129 hour /m ³	0,0083 hour /m ³	Offer < Field
4	<i>Vibratory Roller</i>	0,0150 hour /m ³	0,0091 hour /m ³	Offer < Field
5	<i>Water Tanker Truck</i>	0,0156 hour /m ³	0,0144 hour /m ³	Offer < Field

In terms of costs, the analysis results show that the fixed costs of the machines include depreciation, insurance, and rental fees, which account for about 60% of the total operating costs. Meanwhile, variable costs such as fuel, maintenance, and operator wages account for the remaining 40%. Good management of variable costs proved to be able to reduce total operational costs without reducing the quality of work.

Fuel efficiency is an important factor in controlling variable costs. With fluctuating fuel prices, optimizing the use of heavy equipment is a strategic step to reduce costs. This idle time was caused by sub-optimal coordination between wheel loader and dump truck activities, resulting in queues in the material loading process. The proposed solution is to increase the number of dump trucks or improve the work schedule to reduce the idle time.

In terms of operator performance, the study found that operator expertise contributed significantly to machine productivity. Operators with more than five years of experience were able to achieve work efficiency of up to 90%, compared to operators with less than three years of experience who only achieved 75%. Continuous training for operators is recommended to improve operational efficiency.

Tabel 3 Comparison of Equipment Rental Costs

No	Type of Equipment	Equipment Rental Costs		Description
		Supply Data	Field Data	
1	<i>Wheel Loader</i>	Rp 355.437,61	Rp 230.811,07	Offer > Field
2	<i>Dump Truck</i>	Rp 502.546,95	Rp 312.633,17	Offer > Field
3	<i>Motor Grader</i>	Rp 558.514,78	Rp 354.768,87	Offer > Field
4	<i>Vibratory Roller</i>	Rp 468.414,78	Rp 304.100,87	Offer > Field
5	<i>Water Tanker Truck</i>	Rp 378.025,32	Rp 249.925,32	Offer > Field
Total		Rp 2.262.939,43	Rp 1.440.148,29	Offer > Field

As part of the cost analysis in a construction project, comparing the unit prices of equipment obtained from bid data with the unit prices recorded in the field can provide a clear picture of cost efficiency.

Tabel 4 Comparison of Total Unit Prices of Equipment

No	Type of Equipment	Total Unit Prices of Equipment		Description
		Supply Data	Field Data	
1	<i>Wheel Loader</i>			
2	<i>Dump Truck</i>			
3	<i>Motor Grader</i>	Rp 125.266,66/m ³	Rp 70.686,09 /m ³	Offer > Field
4	<i>Vibratory Roller</i>			
5	<i>Water Tanker Truck</i>			

Further analysis shows that terrain conditions have a major influence on machine productivity. On stable and flat terrain, machine productivity tends to be higher than on bumpy or muddy terrain. Therefore, terrain improvement before construction work begins is a factor to consider in project planning.

From the research results, it was found that synchronization between heavy equipment and time management is a key factor in improving project efficiency. For example, matching the number of dump trucks with wheel loader capacity can reduce waiting time and improve overall productivity. In addition, implementing real-time machine monitoring technology can help identify operational issues more quickly.

In the aspect of graded pavement, the analysis shows that the level of material density achieved by the vibratory rollers is highly dependent on the number of passes and wheel pressure. Given these parameters, the use of vibratory roller with larger wheel specifications can increase the efficiency of the work. However, this also results in increased fuel costs that need to be taken into account.

This research also evaluates the sustainability aspect of heavy equipment use. The use of newer, more energy-efficient machines can be a long-term solution to reduce operational costs and environmental impacts. In addition, regular scheduled maintenance can extend the life of heavy equipment and reduce the risk of unexpected damage.

In further discussion, this study highlights the importance of quality control in graded pavement works. The field results show that the quality of the pavement produced is in accordance with the set technical standards, but there is still potential for improvement through more homogeneous material selection and machine optimization.

Good project management is also an aspect discussed in this research. Effective coordination between contractors, operators, and field supervisors is a key factor in

achieving project targets. By utilizing real-time productivity and cost data, more informed decisions can be made to overcome obstacles in the field.

The results of this study provide important insights for the planning and execution of future infrastructure projects. Improving the efficiency of heavy equipment not only has an impact on reducing costs, but also on accelerating project completion times. As such, the results of this study can serve as a useful reference for stakeholders in the construction industry. Overall, this research confirms the importance of a holistic approach to machine management. By integrating productivity, cost, and quality analysis, construction projects can be run more efficiently and effectively. This is in line with the government's efforts to improve infrastructure quality.

5. CONCLUSION

This study concludes that the productivity and cost of heavy equipment have a very important role in the success of graded pavement work in the Syamsudin Noor International Airport access road construction project. The productivity of heavy equipment, such as wheel loader, dump trucks, motor grader, water tanker trucks and vibratory roller, is influenced by the capacity of the equipment, operator skills, and terrain conditions. Synchronizing work between heavy equipment is a key factor in improving operational efficiency and reducing idle time, so that overall productivity can be improved.

In terms of costs, the analysis shows that effective management of fixed and variable costs can reduce the total operational costs of the project. Optimizing the use of fuel, regular maintenance of heavy equipment, and the use of monitoring technology are strategic steps to maintain cost efficiency without compromising the quality of work. In addition, the equipment rental cost based on field data is lower than the bid, with a difference of Rp 822,791.14 per hour. When calculating the unit price of equipment for the upper base layer work, the unit price in the field is lower than the bid, with a difference of Rp 70,686.09/m³. Meanwhile, the unit price for the upper base layer work is also lower in the field compared to the bid, with a difference of Rp 60,038.63/m³.

In conclusion, the success of a construction project depends not only on the selection of appropriate heavy equipment, but also on careful planning, good time management, and integrated quality control. The results of this research are expected to

be a practical guide for contractors, consultants, and other stakeholders in improving the efficiency and effectiveness of infrastructure project implementation, especially in Indonesia.

LITERATURE

- Ahuja, H. N., Dozzi, S. P., & AbouRizk, S. M. (1994). *Project Management: Techniques in Planning and Controlling Construction Projects*. Wiley.
- Arditi, D., & Lee, D. E. (2003). Assessing the cost effectiveness of quality management practices in construction. *Journal of Construction Engineering and Management*, 129(1), 96-103.
- Callahan, M. T., Quackenbush, D. G., & Rowings, J. E. (1992). *Construction Project Scheduling*. McGraw-Hill.
- Clough, R. H., Sears, G. A., & Sears, S. K. (2000). *Construction Project Management*. John Wiley & Sons.
- Hendrickson, C. (2008). *Project Management for Construction: Fundamental Concepts for Owners, Engineers, Architects, and Builders*. Prentice Hall.
- Kramer, C. (2019). Heavy equipment productivity analysis for road construction projects. *International Journal of Construction Management*, 19(4), 345-352.
- Levin, P. (1998). *Construction Contract Claims, Changes & Dispute Resolution*. ASCE Press.
- Peurifoy, R. L., Schexnayder, C. J., Shapira, A., & Schmitt, R. L. (2011). *Construction Planning, Equipment, and Methods*. McGraw-Hill.
- Soeharto, I. (1999). *Project Management: From Conceptual to Operational*. Erlangga.
- Willis, C. J., & Willis, J. A. (1986). *Practice and Procedure for the Quantity Surveyor*. Collins Professional and Technical Books.