

RISK MANAGEMENT ANALYSIS IN THE OPERATIONAL PERFORMANCE EVALUATION OF HEAVY EQUIPMENT DURING THE JAKARTA LRT PHASE 1A PROJECT EXECUTION

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ABSTRACT

The construction of mass transportation infrastructure, such as the Light Rail Transit (LRT), relies heavily on the performance of heavy equipment as a key factor in project success. Heavy equipment production capacity is a crucial aspect in determining whether work targets are met according to the implementation schedule. This study aims to evaluate production volume capacity for the Jakarta LRT Phase 1A project by analyzing the performance of heavy equipment, including cranes, excavators, dump trucks, compactors, and other supporting machinery. A volumetric method was employed to calculate production capacity and equipment productivity. The analysis results indicate that the achieved heavy equipment productivity met the required work volumes in accordance with the project's planned targets and schedule.

Keywords: Heavy Equipment, Productivity, Production Capacity, LRT, Construction Management

INTRODUCTION

In implementing large-scale civil engineering construction projects, heavy equipment has an important role in supporting the successful and efficient completion of work. The use of heavy equipment is not only applied in the construction sector, but also in the agricultural, forestry and mining sectors. Heavy equipment performance is influenced by various aspects, such as maintenance costs, operational costs, technical specifications, work characteristics, terrain conditions, and the duration of project implementation. Therefore, selecting heavy equipment that suits work needs is an important factor in optimizing productivity and preventing increased costs and project delays. In the Jakarta Phase 1A LRT project, earthworks are the main stage in preparing the land and ensuring the stability of the rail line structure and supporting facilities. The success of earthworks is determined by the management of soil conditions, the drainage system, and the readiness of the land for the next construction phase. To support the effectiveness of the work, various types of heavy equipment are used, such as Excavators for digging and loading materials, Dump Trucks for transporting soil, Dozers for leveling piles, Motor Graders for surface smoothing, and Vibratory Rollers for the soil compaction process. The use of this combination of heavy equipment aims to increase productivity and ensure construction work goes according to plan.

METHODS

The research method in this project is arranged in the form of a flow chart which shows the research stages systematically, including the preparation stages, data collection, data processing, and analysis of research results. The presentation of this flow aims to provide an overview of the research process that is structured, clear and scientifically accountable.

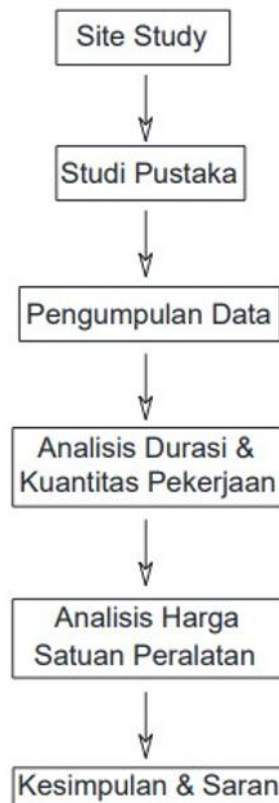


Figure 1. Research Flowchart

A literature review was conducted by examining various relevant reference sources, particularly books and scholarly literature regarding the use of heavy equipment in road construction projects. In addition to secondary data from the literature, primary data were obtained through direct observation at the project site. Field data collected included information on heavy equipment operating costs, work execution plans, and the scope of work performed. The types of heavy equipment used by the contractor to support on-site construction activities included the following:

- 1) Asphalt Sprayer
Sprays liquid asphalt (prime coat/tack coat) evenly onto the pavement surface prior to asphalt laying.
- 2) Asphalt Finisher
Spreads and levels the hot mix asphalt according to the planned thickness and slope.
- 3) Hydraulic Excavator
Performs excavation, earthmoving, dredging, and other construction tasks using a hydraulic system.
- 4) Motor Grader
Levels, shapes, and finishes soil surfaces or aggregate layers according to design elevations and slopes.

5) Vibration Roller

Compacts soil, aggregate, or pavement layers using a combination of downward force and vibration to increase material density.

6) Tronton Truck

Transports large quantities of construction materials—such as aggregate, soil, or other materials—from the source to the project site.

7) Stone Crusher;

8) Pneumatic Tired Roller;

9) Asphalt Mixing Plant;

10) Compressor;

11) Dump Truck;

12) Tandem Roller;

13) Wheel Loader.

Loading, moving, and stacking materials such as soil, sand, or aggregates using a bucket attached to the front of the machine.

The cycle times to be calculated are those of the dump truck, hydraulic excavator, and wheel loader.

1) Dump truck

The following equation can be used to calculate the dump truck cycle time:

$C_m = C_{m1} + C_{m2} + C_{m3}$; where C_m = cycle time, C_{m1} = fixed time (minutes), C_{m2} = loading time, and C_{m3} = travel time.

2) Hydraulic excavator

The excavator cycle time can be determined based on Figure 2 below.

Observation	1	2	3	4	5	Average
Time taken to assume the loading position	1,2	1,35	1,5	1,27	1,4	1,34
Loading time	13,9	13,9	13,9	13,9	13,9	13,9
Lifting time	54	55	65	57	56	57,60
Unloading time	13	12	13	14	11	12,60
Time to return	25	24	23	25	24	24,20

Figure 2. Excavator Cycle Time

3) Wheel loader

The wheel loader has a fixed time of approximately 9.1 seconds. The loading process is determined using the V-loading method: $C_m = 2 \left(\frac{D}{F} + \frac{D}{R} \right) + z$; where C_m = cycle time

(minutes), D = haul distance (m), F = forward speed (m/min), R = reverse speed (m/min), and Z = fixed time (minutes).

The specifications of the heavy equipment used in this project are as follows:

1) Hydraulic excavator

Type: Komatsu PC500LC-10 R

Bucket capacity: 2.5 m³

Net engine output: 260 HP

2) Asphalt finisher

Paving width: 2.7 m – 5 m

Hopper capacity: 8 tons

Type: Mitsubishi MF55H

RESULTS AND DISCUSSION

The project implementation schedule is developed using a structured planning method that comprehensively considers every stage of the work. This schedule serves as a reference for organizing the sequence of project activities—including work order, estimated execution time, and resource requirements—to ensure the construction process proceeds optimally, effectively, and efficiently. Based on the agreed-upon work plan, the Jakarta LRT Phase 1A Project is scheduled for completion within 270 effective working days. This schedule accounts for various technical aspects, site conditions, resource availability, and potential constraints that could impact the workflow. The heavy equipment mobilization phase is estimated to require approximately 50 effective working days; this encompasses transporting equipment from its origin to the project site, initial setup, and operational preparation to ensure all equipment is ready for use as required. Following mobilization, finishing activities—comprising construction refinements, final site arrangement, detail adjustments, and quality inspections—are estimated to require an additional 25 effective working days. Consequently, the total time allocated from mobilization through to final completion is approximately 70 effective working days. All duration estimates have been integrated into the comprehensive project schedule to ensure each work stage meets its established deadline. Therefore, calculating heavy equipment volume and productivity is a crucial factor in ensuring the smooth execution of primary work activities, as shown in Table 1.

Table 1. Operational Activity Production Capacity

No.	Activity Type	Effective Work Time	Production Capacity	
			/ day (m ³)	/ hour (m ³)
1.	Excavation	30	501,77	71,71
2.	Stockpile	10	378,81	36,11
3.	Aggregate Base Course	17	42,10	4,80
4.	Asphalt Pavement	5	56,87	7,61

This study analyzes the production capacity of heavy equipment to assess the effectiveness and efficiency of construction equipment utilization in earthworks. The analysis involves calculating the production capabilities of the vehicles and heavy machinery used on-site by considering various parameters, such as equipment technical specifications, operational conditions, effective working time, and project environmental and terrain conditions. Key aspects of this study include evaluating cycle times, the volume of material moved per work cycle, and equipment usage efficiency factors during operations. A thorough understanding of the relationship between cycle time, production capacity, and operational efficiency is crucial for determining heavy equipment performance, thereby ensuring that work volume targets are optimally achieved in accordance with the established project schedule and productivity plans.

Table 2. Cycle Time Analysis for Earth Excavation Work

No.	Equipment Used	Cycle Time
1.	Dump Truck	50
2.	Hydraulic Excavator	30

The analysis of production volume capacity aims to determine the hourly working capacity of heavy equipment based on topographical conditions. Cycle time must be calculated first, as it serves as the basis for this analysis. The evaluation takes into account the actual on-site usage of the equipment, covering technical and operational aspects, duration, and efficiency. The analysis results are presented in full in Table 3 to facilitate understanding.

Table 3. Analysis of Heavy Equipment Volume Quantities for Soil Embankment Activities

No.	Heavy equipment	Heavy Equipment Volume Quantity
1.	Dump Truck	21,13 hour (m ³)
2.	Motor Grader	17,10 hour (m ³)
3.	Vibration Roller	11,66 hour (m ³)
4.	Wheel Loader	39,70 hour (m ³)

Heavy equipment productivity is calculated based on site conditions, including cycle times, topography, and the operational efficiency of each piece of equipment. The results are summarized in Table 4, providing an overview of actual on-site productivity that can serve as a reference for evaluation during project execution.

Table 4. Average Heavy Equipment Quantities for Soil Excavation Activities

No.	Heavy Equipment Used	Work Volume	Heavy Equipment Volume Capacity	Effective Working Time	Number of Tools
		hour (m ³)	hour (m ³)		
1.	Dump Truck	56,55	147,31	37	5
2.	Hydraulic Excavator		41,61		7

CONCLUSIONS

This project is estimated to be effectively completed within 77 working days, based on calculations of optimal production capacity and realistic activity durations. Furthermore, specific operational vehicles have been selected to suit job requirements and site conditions, including:

- 1) Wheel loader.
- 2) Vibration roller;
- 3) Tandem roller;
- 4) Pneumatic tired roller;
- 5) Motor grader;
- 6) Hydraulic excavator;
- 7) Asphalt finisher;
- 8) Dump truck;

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