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ANALYSIS OF HEAVY EQUIPMENT PRODUCTIVITY IN THE JALAN REL KOTA LANGSA RECONSTRUCTION PROJECT

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ABSTRACT

The quality of the road produced during the reconstruction of Jalan Rel Kota Langsa is directly dependent on the materials used, the operators, and the application of heavy equipment. Errors in heavy equipment selection will lead to low productivity. This study aims to determine the productivity levels and the required duration for each piece of equipment to complete the Langsa City Road Reconstruction project. This research employs the Bina Marga method with a quantitative approach. The analysis results show that the productivity of heavy equipment for Aggregate Base Class A (LPA) work is as follows: dump trucks = 386.352 m^3/day, motor graders = 617.143 m^3/day, vibrator compactor rollers = 804.270 m^3/day, and water tanks = 498 m^3/day. For prime coat work: air compressors = 3486 m^2/day and asphalt distributors = 647.089 liters/day. For Asphalt Concrete-Binder Course (AC-BC) work: dump trucks = 172.148 m^3/day, asphalt finishers = 804.270 tons/day, tandem rollers = 401.017 m^3/day, and pneumatic tire rollers = 365.776 m^3/day. The duration required for heavy equipment execution is 2 days for LPA work, 1 day for prime coat work, and 2 days for AC-BC work.

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A. BACKGROUND

In general, road infrastructure is constructed to facilitate mobility and accessibility for socio-economic activities within society. The existence of roads is essential to support the pace of economic growth, trade, and other sectors. The rapid development of infrastructure has driven current improvements and construction projects. It is undeniable that these contemporary construction efforts are inseparable from the use of supporting tools, specifically heavy equipment (Fihani et al., 2021).

Heavy equipment refers to machinery used to assist human activities in construction projects. This equipment is vital, particularly for projects related to construction, mining, and other large-scale operations. The primary purpose of utilizing heavy equipment is to streamline human labor, ensuring that objectives are met more efficiently and within a relatively shorter timeframe. (Ramdhani & Johari, 2021; Suryawan, 2020)

Jalan Rel Kota Langsa is a primary local road that plays a vital role in supporting economic sector development, as it connects national activity centers with local community activity centers. In 2024, reconstruction was carried out on Jalan Rel to enhance the accessibility of the community's socio-economic activities. Reconstruction is defined as the handling and structural upgrading aimed at improving the capacity of road sections in severely damaged condition, ensuring that the road can be restored to a stable state in accordance with its design life (PUPR, 2011).

The reconstruction of Jalan Rel Kota Langsa is inseparable from the quality of the resulting road, which is fundamentally influenced by the materials, operators, and the use of heavy equipment to ensure that the outcome aligns with the plan and is completed within the specified timeframe. Furthermore, the utilization of heavy equipment significantly impacts the progress of a project's activities (Jaya & Sutandi, 2019). Incorrect selection of heavy equipment leads to suboptimal productivity; consequently, additional costs will be incurred for maintenance and the acquisition of other heavy machinery.(Nugraha et al., 2018; Purwanto et al., 16 C.E.).

In the Jalan Rel Kota Langsa reconstruction project, specifically for the Class A aggregate base and AC-BC (Asphalt Concrete-Binder Course) works, the heavy equipment utilized includes dump trucks, motor graders, vibratory compactor rollers, water tank trucks, air compressors, asphalt distributors, asphalt finishers, tandem rollers, and pneumatic tire rollers. A dump truck serves as a long-distance transport vehicle for hauling materials such as soil, sand, and rocks from construction sites, traversing routes that may include flat roads, inclines, and declines. The operator plays a crucial role in managing loading times, as the productivity of both hauling and excavation equipment is determined during the loading process (Amin & Khotibul umam, 2022; Sokop et al., 2018). A Motor Grader is a heavy equipment unit designed for soil leveling and surface shaping. The blade of the motor grader can be adjusted in such a way that it can function as an angle dozer or a tilting dozer, making it significantly more flexible than standard dozer types. (Setiawati & Meddeppunge, 2013).

A vibratory roller compactor, also known as a vibratory roller, is a compaction tool that generates dynamic forces on the soil. The vibration causes soil particles to fill the voids between them, resulting in a denser and more compact soil structure (Amin & Khotibul umam, 2022). A water tank truck is a vehicle designed to serve as a water transport unit for various activities, including road watering during the compaction process and dust suppression to prevent dust during road construction (Ismuhadi, 2020; Retno, 2013).

An air compressor is utilized as a source of high-pressure air power for jackhammers, rock drills, or concrete breakers during demolition activities. It is also used to clean the work area of debris and dust in preparation for the application of prime coats or tack coats (PUPR, 2023). An asphalt distributor is a truck modified according to its specific function. The primary purpose of this equipment is to spread liquid asphalt onto the road foundation surface at a constant speed. The distributor's tank is equipped with a system to maintain the asphalt's temperature, and it also features a burner designed to increase the temperature in accordance with specified requirements. (Rostiyanti, 2008). An asphalt finisher is a machine used to spread asphalt mixtures produced by an asphalt mixing plant. There are two types of asphalt finishers: the crawler type, which utilizes tracks, and the wheel type, which uses rubber tires(Wilopo, 2009).

Tandem rollers are typically utilized for the initial and final compaction stages of asphalt work, as their primary function is to level the surface. However, they are not used on hard or sharp rock surfaces, as such conditions can cause damage to the drums (Purnomo, 2021; Rostiyanti, 2008). A Pneumatic Tire Roller performs the compaction process using a combination of kneading action and static weight. The machine's total weight, the adjustment of tire pressure (both increasing and decreasing), the tire width configuration, and the regulation of contact pressure are all methods used to control the compaction force applied to the soil surface (RaynontoM.Y et al., 2023; Rostiyanti, 2008). The heavy equipment will be analyzed to determine its productivity and working duration based on the Minister of Public Works and Housing Regulation (Permen) No. 8 of 2023 concerning the Guidelines for Preparing Construction Cost Estimates (PUPR, 2023).

Based on the background described above, it is necessary to conduct a research on heavy equipment productivity analysis within construction projects. This study aims to determine the productivity rates and work durations of each piece of equipment utilized in the Jalan Rel Kota Langsa reconstruction project.

B. METHODOLOGY

This study employs the Bina Marga method with a quantitative approach. The analysis is conducted on the productivity or production capacity of heavy equipment, specifically: dump trucks, motor graders, vibratory compactor rollers, water tank trucks, air compressors, asphalt distributors, asphalt finishers, tandem rollers, and pneumatic tire rollers, in accordance with the established formulas PUPR, (2023).

Based on the Regulation of the Minister of Public Works No. 11/PRT/M/2013 (Umum, 2010), productivity is defined as the ratio between output and input, which includes labor, materials, equipment, and time. For analytical purposes, productivity is measured as the comparison of output against both input and time. High productivity occurs when the resources and time consumed (input and time) are relatively low while generating a significant output. In this context, such high productivity indicates that the management of heavy equipment assets has not been optimized, both in terms of equipment availability and the management of users or lessees (Kengke et al., 2019).

1. Project Timeline

The essential factors to consider when determining work duration are the total volume of work to be performed and the productivity of the equipment. Equipment production depends on its capacity and cycle time. This is measured by comparing the achieved output with the total resources utilized (input). The formula that can be used to calculate the duration is as follows (Rostiyanti, 2008):

$$\text{Duration} = \frac{\text{work volume}}{\text{heavy equipment productivity}}$$

2. Research Site

The location of this research is the reconstruction project of Jalan Rel Kota Langsa, from STA. 0+000 to 0+679, as shown in the following figure.

Figure 1. Research location map via Google Earth

3. Research flowchaart

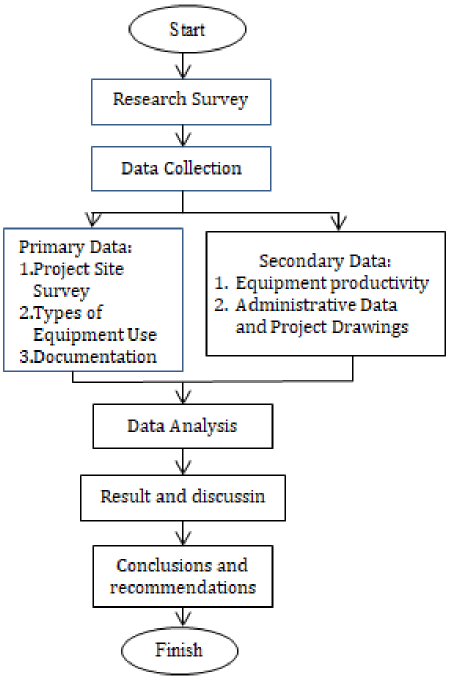

Figure 2. Reaserch Flowchaart

C. RESULT AND DISCUSSION

1. Work Volume

The planning of work volumes is essential for determining the materials, equipment, and labor required for a road construction project. Standard design drawings and applicable technical specifications are used to calculate the volume of each work item. The recapitulation of these work volumes serves as the primary reference for the preparation of the Budget Plan (RAB) and on-site implementation.

Based on the volume analysis for the Jalan Rel Reconstruction project (STA. 0+000 – 0+679), the calculated work volumes are presented in the table below. The scope of work includes:

Table 1. Work Volume Recapitulation

No	Uraian Pekerjaan	Volume	Satuan
1.	Aggregate Base Class A	556,31	m^3
2.	Prime Coat	3081,00	Liter
3.	Asphalt Concrete-Binder Course (AC-BC)	522,23	Ton

Table 1 presents a recapitulation of the total work required to complete the road pavement project. The technical planning results, field requirements, and technical specifications were utilized to calculate the work volume. The types of work summarized include Class A aggregate base courses, prime coats, and AC-BC wearing courses. Each work item is presented with its respective unit and volume, which are used to determine the material requirements and the duration needed for completion.

2. The determines the overall productivity of the heavy equipment

The calculation of heavy equipment production depends on the specific function of the equipment. Since production capacity is typically expressed in cubic meters (m^3) per hour, it is essential to consider the volume produced per cycle and the number of cycles completed per hour. (Amin & Khotibul umam, 2022; Rumbyarso, 2023). The summary of heavy equipment productivity is presented in the following table.

Table 2. Summary of Havy Equipment Productivity

No	Work Description	Equipment Name	Produktivity	unit
1	LPA	Dump truck	386,352	$m^3/hari$
		Motor Grader	617,143	$m^3/hari$
		Vibratory Compactor Roller	804,27	$m^3/hari$
		Water Tannk	498	$m^3/hari$
2	Prime Coat	Air Compressor	3486	$m^2/hari$
		Asphalt Distributor	19173	$liter/hari$
3	AC-BC	Dump truck	172,148	$m^3/hari$
		Asphalt finisher	647,089	$ton/hari$
		Tandem Roller	401,017	$m^3/hari$
		Pneumatic Tire Roller	365,776	$m^3/hari$

3. Work Duration

a. The work duration for the aggregate base course

$$time = \frac{work\ volume}{Daily\ Dump\ Truck\ Output} = \frac{677{,}572\ (gembur)}{386{,}352} = 1{,}728\ Days \approx 2\ hDays$$

$$time = \frac{work\ volume}{Daily\ Grader\ Output} = \frac{556{,}31}{617{,}143} = 0{,}901\ Days\ \approx 1\ Day$$

To align with the duration required for the dump trucks to deliver the Aggregate Base Class A (LPA) material, the duration for the motor grader to spread the material is adjusted to approximately 2 days

$$time = \frac{work\ volume}{Daily\ Compact\ Output} = \frac{556{,}31}{804{,}27} = 0{,}692\ Days\ \approx 1\ Day$$

By adjusting to the duration of the motor grader spreading the Aggregate Base Class A (LPA), the compaction duration for the vibratory compactor roller is approximately 2 days

$$time = \frac{work\ volume}{Daily\ Water\ Tank\ Output} = \frac{556{,}31}{498} = 1{,}117\ Days\ \approx 2\ Days$$

The required duration for the vibratory roller compactor to compact the Aggregate Base Class A is approximately 2 days

Based on the production capacity calculations for a total volume of 556,31 m^3, the time required to spread and compact the material is 2 working days.

b. Duration of Prime Coat Application

$$time = \frac{Work\ volume}{Daily\ Air\ Compressor\ Output} = \frac{3793\ m^2}{3486} = 1{,}06\ days \approx 1\ Day$$

The duration required for cleaning the Aggregate Base Class A (LPA) surface and applying the prime coat—based on heavy equipment production capacity calculations for a volume of 3,081 liters—is one working day.

c. The work duration for the asphalt concrete-Binder course (AC-BC)

$$time = \frac{Work\ volume}{Daily\ ump\ truck\ Output} = \frac{278{,}523\ (gembur)}{172{,}148} = 1{,}618\ days \approx 2\ days$$

$$time = \frac{Work\ volume}{Daily\ asphalt\ finisher\ Output} = \frac{522{,}23}{647{,}089} = 0{,}807\ days\ \approx 1\ day$$

Adjusting to the travel duration of dump trucks transporting the AC-BC material, the duration for the asphalt finisher to spread the AC-BC is estimated to be approximately 2 days.

$$time = \frac{work\ volume}{Daily\ tandem\ output} = \frac{278{,}523}{401{,}017} = 0{,}695\ days\ \approx 1\ day$$

In accordance with the duration of the asphalt finisher spreading the AC-BC, the compaction duration for the tandem roller is approximately 2 days

$$rime = \frac{work\ volume}{Daily\ PTR\ output} = \frac{278{,}523}{365{,}776} = 0{,}761\ Days\ \approx 1\ day$$

In accordance with the duration of the asphalt finisher for spreading AC-BC, the compaction time required for the pneumatic tire roller is approximately two days.

The work duration for the Asphalt Concrete Binder Course, based on heavy equipment production capacity calculations for a road length of 679 m, a width of 5.5 m, and a thickness of 0.06 m, is 2 working days. All details regarding the aforementioned work duration are presented in the following table:

Table 3. Recapitulation Of Work Duration

No	Scope of Work	Duration
1.	LPA	2 Days
2.	Prime Coat	1 Day
3.	AC-BC	2 Days

D. CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis and discussion of heavy equipment productivity and work duration for the Jalan Rel Kota Langsa Reconstruction project, the following conclusions are drawn:

1. The productivity of heavy equipment for Aggregate Base Class A (LPA) work is as follows:
   a. For the transport of Class A aggregate material using 10 units of dump trucks with a 8.5-ton capacity and a haul distance of 15 km, the productivity is 38,635 m^3/day perunit.
   b. For the spreading of Class A material using a motor grader (on a road section with a length of 679 m, width of 5.5 m, and layer thickness of 0.15 m), the productivity is 617,143 m^3/day.
   c. The productivity of a vibratory roller compactor for Class A material compaction is 804,270 m^3/day
   d. The productivity of a water tank truck for Class A material compaction is 498 m^3/day.
2. The productivity of heavy equipment for prime coat application is detailed as follows:
   a. The productivity of the air compressor for base course surface cleaning is 3486 m^2/day.
   b. The productivity of the asphalt distributor for prime coat application is 9173 liter/day.
3. The productivity of heavy equipment for the Asphalt Concrete-Binder Course (AC-BC) work is as follows:
   a. For material transportation, using 10 units of dump trucks with a capacity of 8.5 tons and a hauling distance of 15 km, the productivity is 172,148 m^3/day
   b. The productivity for the spreading process using an asphalt finisher, with a layer thickness of 0.06 m, is 647.089 tons/day.hari.

c. For the initial compaction process, the productivity of the tandem roller is 401,017 m^3/day.
d. For the intermediate compaction process, the productivity of the pneumatic tire roller is 365,776 m^3/day.

4. Based on the calculation of heavy equipment productivity, the time required to complete the work using heavy equipment is as follows:
   a. The duration for Aggregate Base Class A (LPA) work is 2 days.
   b. The duration for Prime Coat work is 1 day.
   c. The duration for Asphalt Concrete-Binder Course (AC-BC) work is 2 days.Waktu pekerjaan AC-BC adalah 2 hari

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