

Performance Analysis of Mojokerto -Batu Transportation

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Abstract: Public transit performance evaluation is a process to measure the effectiveness and efficiency of services, including frequency, punctuality, capacity, and passenger comfort. Public transit services that fail to meet the needs of the community will lead to a decrease in trust and encourage people to switch to private vehicles. This study aims to evaluate the performance of Mojokerto-Batu transportation, particularly in terms of travel time, waiting time, load factor, fleet frequency, average speed, and travel time. The research method used is performance analysis based on time measurements and operational parameters. The results of the study show that the time between Mojokerto-Batu transportation is 1 hour 46 minutes 12 seconds, the waiting time for passengers on the Mojokerto-Batu route is 53 minutes 6 seconds, the average load factor of Mojokerto-Batu transportation is 23.83%, the fleet frequency of Mojokerto-Batu transportation is 0.565 vehicles/hour, the travel time of Mojokerto-Batu transportation is 2.27 minutes/km, and the average speed of Mojokerto-Batu transportation is 26.67 km/hour. The implications of this study suggest the need for improvements in public transport management to enhance efficiency, comfort, and punctuality to reduce reliance on private vehicles and increase public trust in public transport services.

Keywords: Public Transportation, Performance, Evaluation

Introduction

Population growth in urban areas and increased mobility needs are major challenges in Indonesia's transportation system (Sunitiyoso et al., 2023). Efficient mobility is essential to support economic activity and improve people's welfare (Lin & Cui, 2021). In this context, public transport plays an important role as the backbone of urban transportation (Xu et al., 2022). However, with more private vehicles on the road, problems such as congestion, increased air pollution, and longer travel times arise (Wang & Zhong, 2023). Therefore, there is a need to evaluate and integrate public transport systems to ensure that public transport can function optimally and is well connected (Ceder, 2021).

Public transit performance evaluation is a process of measuring the effectiveness and efficiency of services, including frequency, punctuality, capacity, and passenger comfort (Ait-Ali, 2024). Public transit services that cannot meet people's needs will cause a decline in trust and encourage people to switch to private vehicles (Walker, 2024). As a result, the use of public transportation decreases and the burden on roads increases. Public transit research and evaluation aims to identify existing barriers and formulate solutions in the form of route planning, fare integration, and infrastructure improvement (Ceder, 2021b).

The benefits of public transport evaluation and integration are not only in the form of increased convenience for users, but also contribute to reduced congestion and reduced greenhouse gas emissions. Increased use of public transport reduces the number of private vehicles on the road, thereby improving air quality and reducing transportation operating costs (AlKheder, 2021). In addition, a good public transport system also promotes economic growth by facilitating access to economic and social centers (Prus & Sikora, 2021).

Materials and Methods

The analysis method used in this research is descriptive quantitative method. While quantitative research is a research approach that uses numerical data or numbers as a basis for answering research

questions, testing hypotheses, or understanding certain phenomena (Ghanad, 2023). This method focuses on measuring variables objectively and analyzing data statistically to identify patterns, relationships, or differences between variables (Dehalwar & Sharma, 2023). This research focuses on the performance of AKDP (Inter City Within Province) public transportation on the Mojokerto-Batu route.

The parameters/performance indicators of public transport that will be analyzed in this study include those listed in the table below:

Table 1. Public Transport Performance Standards

No.	Parameters	Standard
1	Headway	5 - 10 minutes
2	Lay Over Time	5 - 10 minutes
3	Load Factor	70 %
4	Frequency	12 kend/hour
5	Time	>1.5 Hours
6	Spee	25 km/h

Source: Director General of Transportation Decree No. 687 Year 2002

1. Time Between

Is the time interval or distance between one city transportation vehicle and the city transportation vehicle behind it to go through a certain point.

2. Waiting Time

The time required by transit service users to wait for public transportation until the arrival of the transportation. Waiting time is strongly influenced by the frequency of the transportation using the function of vehicle headway.

$$Wt = 0.5 \times H \text{ (minutes) (5)}$$

Where:

H = *Headway*

3. Load Factor

Is the ratio of the number of passengers carried in the vehicle to the total capacity of the vehicle during one pass. The purpose of this analysis is to determine the average number of passengers carried on each section of the transportation route in accordance with existing demand.

$$LF = \frac{JP}{C} \times 100 \%$$

Where

LF = *Load Factor* (%)

JP = The number of passengers carried along one one-way track.

C = vehicle capacity

4. Frequency

The frequency value is obtained from the number of vehicles on each route that pass through the road section and exit or enter the terminal in a certain unit of time.

$$F=1H \text{ (4)}$$

Where:

F = frequency (kend/hour)

H = headway (hour/kend)

5. Time

The calculation of travel time is used to determine the round trip time of one vehicle on the route or in other words the round trip time. Travel time is calculated when the vehicle starts to depart until the vehicle returns and is added to the length of time the vehicle is at the terminal and the time to pick up and drop off passengers.

$$W = TJ \quad (3)$$

Where

W = Public transport travel time (min/km)

T = Public transport travel time (minutes)

J = Public transportation distance (km)

6. Speed

It is the average speed of vehicles recorded when passing through a predetermined section which is obtained from the length of the route and the travel time of each route.

$$V = st$$

Where

V = Travel speed of public transport

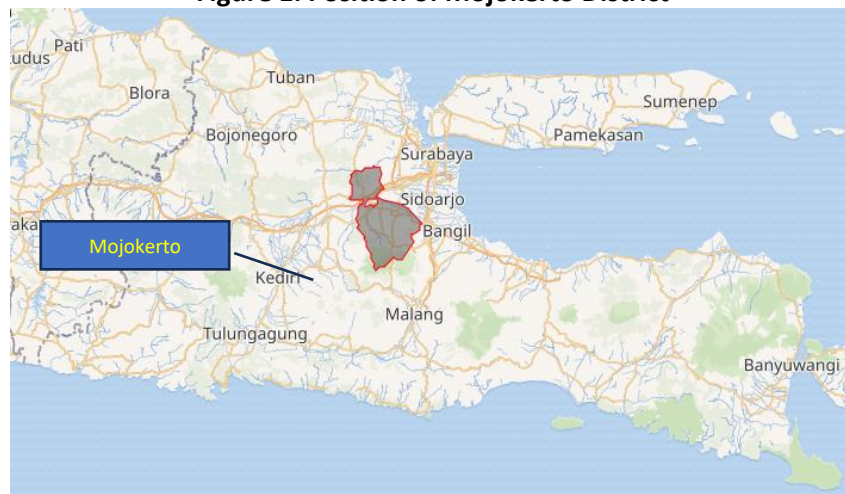
Results and Discussion

1. Overview of the Study Area

a) Overview of Mojokerto District

Mojokerto District Astronomically, Mojokerto District is located between $111^{\circ}20'13''$ $111^{\circ}40'47''$ east longitude and between $7^{\circ}18'35''$ to $7^{\circ}47'0''$ latitude. Based on its geographical position, Mojokerto district has the following boundaries: North - Lamongan Regency and Gresik Regency; South - Malang Regency; West - Jombang Regency; East - Sidoarjo Regency and Pasuruan Regency. Based on its geographical location, Mojokerto district is in a land area surrounded by. Mojokerto district has 18 sub-districts. The position of Mojokerto District in relation to East Java Province can be seen in the figure below.

Figure 1. Position of Mojokerto District



Source: Google Map

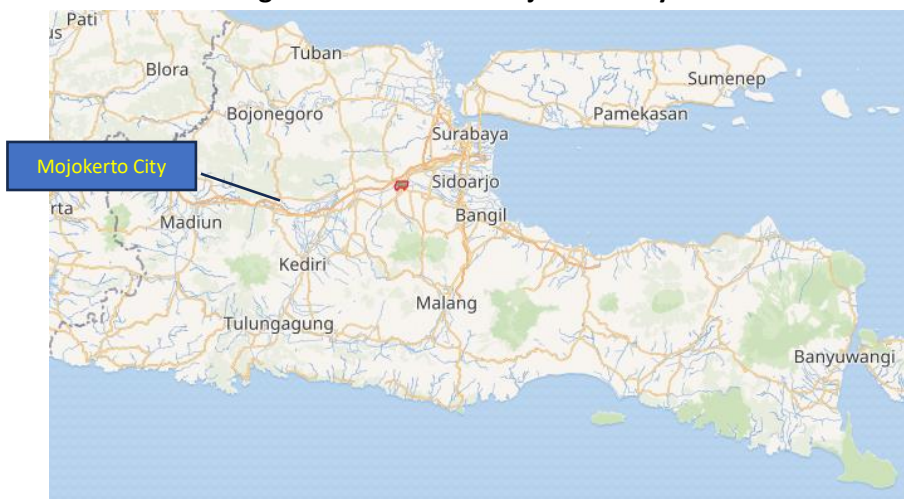
The length of existing district roads in Mojokerto district is 1,041.32 km. To support smooth transportation access, the Mojokerto district government has built 607 bridges consisting of 240 concrete bridges, 228 composite bridges, 36 iron bridges and 103 other bridges (*source: Mojokerto district in figures 2024*).

Mojokerto district is also a city of industry and tourism. There are several industries in Mojokerto district, including Ngoro Industrial Park and several other industries. While tourism in Mojokerto district includes Kaye Putih Hill which is adjacent to the Trans-Jatim Corridor 3 track.

b) Overview of Mojokerto City

Astronomically, Mojokerto City is located between 7° 28' South latitude and between 112° 26' East longitude with an area of 20.21 km². The area consists of 3 sub-districts, and 18 urban villages. Based on its administrative boundaries and geographical position, Mojokerto City shares a boundary with Mojokerto Regency.

Figure 2. Position of Mojokerto City



Source: Google Map

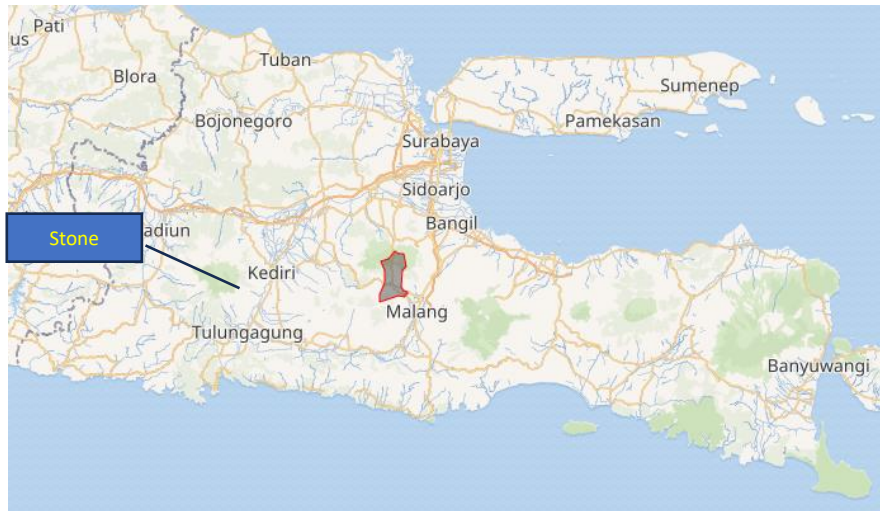
The length of roads in Mojokerto City in 2023 reached 188.19 km with 152.08 km of good roads, 30.23 km of medium roads and 5.89 km of lightly damaged roads. During 2023, the number of passenger transportation routes was 706,678 (*source: Mojokerto city in figures 2024*).

Terminal Kertajaya Mojokerto is a type B terminal located in Mojokerto City and is the meeting point for Mojokerto-Batu transportation and Trans-Jatim Corridor 3 (Mojokerto-Gresik) transportation.

c) Overview of Batu City

Batu City is a tourist city in East Java Province. The Batu City area is located at the foot and slopes of the mountains and is at an average altitude of 700-1,800 m above sea level with an average air temperature reaching 11-22 degrees Celsius. Batu City is often a tourist destination for people in East Java. Batu City borders Malang Regency on the sides, west, and east, while on the north side Batu City borders Mojokerto Regency.

Figure 3. Position of Batu City



Source: Google Map

Batu Terminal is a type B terminal that is a stop for Mojokerto-Batu transportation. Terminal Batu serves inter-city transportation within the province (AKDP), urban transportation, and rural transportation.

2. Overview of Mojokerto - Batu Public Transportation Services

Public transport serving the Mojokerto - Batu route is an Inter-City Within Province (AKDP) transport service whose route permit is issued by the East Java Provincial Government through the East Java Provincial Transportation Office. The Mojokerto - Batu public transport service was launched by the East Java Provincial Government on January 24, 2024 at Terminal Kertajaya, Mojokerto City. The launch of the Mojokerto - Batu public transportation route is expected to be a feeder for the existing Trans Jatim transportation. The route map of the Mojokerto Batu public transportation route can be seen in the image below

The Mojokerto - Batu route is served by public transport operator PT Bagong Dekaka Makmur using the latest Mitsubishi type vehicles, by passing the route Mojokerto Terminal, Dlanggu Market, Kutorejo, Pacet Roundabout, Cangar, Bumiaji, and Batu Terminal. according to the Route Permit issued by the East Java Provincial Transportation Office that the number of vehicles owned by PT Bagong Dekaka Makmur as an operator serving the Mojokerto Batu route is 16 units with a capacity of 18 passengers.

In accordance with the route permit issued by the East Java Provincial Government through the East Java Provincial Transportation Office, the 16 vehicles serving the route are as follows

Table 2. Number of AKDP Fleet for Mojokerto - Batu route

No.	Vehicle Number	Vehicle Type	Brand	Capacit	Year of Manufacture
1	N 7135 UF	FE 71	MITSUBISHI	18	2019
2	N 7145 UF	FE 71	MITSUBISHI	18	2019
3	N 7275 EU	FE 71	MITSUBISHI	18	2017
4	N 7276 EU	FE 71	MITSUBISHI	18	2017
5	N 7286 UF	FE 71	MITSUBISHI	18	2019
6	N 7288 UF	FE 71	MITSUBISHI	18	2019

No.	Vehicle Number		Vehicle Type	Brand	Capacit	Year of Manufacture
7	N	7347 EU	FE 71	mitsubishi	18	2017
8	N	7348 EU	FE 71	mitsubishi	18	2017
9	N	7412 EU	FE 71	mitsubishi	18	2017
10	N	7415 UF	FE 71	mitsubishi	18	2020
11	N	7421 UF	FE 71	mitsubishi	18	2020
12	N	7511 EU	FE 71	mitsubishi	18	2017
13	N	7825 UF	FE 71	mitsubishi	18	2020
14	N	7826 UF	FE 71	mitsubishi	18	2020
15	N	7977 EU	FE 71	mitsubishi	18	2018
16	N	7982 EU	FE 71	mitsubishi	18	2019

Source: Survey Results

Based on table 2 above, the number of vehicles serving the Mojokerto-Batu route via Cangar according to the route permit issued by the East Java Provincial Transportation Office is 16 vehicles with a capacity of 18 passengers. Vehicles serving the Mojokerto - Batu route were made in 2017-2020, so until now the average age of vehicles serving the route is 5.56 years. The vehicle brand used is Mitsubishi type FE 71.

3. Headway for Mojokerto - Batu Transportation

When viewed from the passenger side (service users) then the lowest intermediate time is the best indicator in public transport services, but the operating costs of the vehicle into consideration of the operator in determining the number of fleets operating. In accordance with the Decree of the Director General of Land Transportation number 687 of 2002, the standard time between (headway) public transport services is as follows

Table 3. Table of Public Transportation Performance Assessment Standards in terms of Time Between (headway)

No.	Service Indicators	Unit	Assessment Standard (minutes)		
			Less	Medium	Good
1	Headway	minutes	>15	10 - 15	<10

Source: Decree of the Director General of Hubdat No. 687 of 2002

To determine the value of time between (headway) a static survey was conducted on November 30, 2024, December 1, 2024, December 2, 2024 and December 3, 2024. While the results of static surveys that have been carried out that the average headway of AKDP Mojokerto-Batu public transportation is as follows:

Table 4. Headway of Mojokerto - Batu Transportation

No.	Survey Date	Directions	Headway
1	November 30, 2024	Mojokerto-Batu	01:45:45
		Batu-Mojokerto	01:46:10
2	December 1, 2024	Mojokerto-Batu	01:45:50
		Batu-Mojokerto	01:46:25
3	December 2, 2024	Mojokerto-Batu	01:46:50

No.	Survey Date	Directions	Headway
		Batu-Mojokerto	01:46:20
4	December 3, 2024	Mojokerto-Batu	01:46:10
		Batu-Mojokerto	01:46:05
Average Headway			01:46:12

Source: Analysis Result

From table 4. above that the average headway of Mojokerto-Batu public transportation is 1 hour 46 minutes 12 seconds or when converted into units of minutes then the headway of Mojokerto-Batu transportation is 106.2 minutes. Based on the Decree of the Director General of Land Transportation, the headway value is included in the poor category.

4. *Waiting Time (Lay Over Time)* Mojokerto - Batu Transportation

The results of the analysis of waiting time (*lay over time*) are directly proportional to the analysis of the time between (*headway*). The longer the *headway* of the transportation fleet, the longer the *lay over time* of passengers in waiting for the departure of the transportation fleet. standard waiting time in accordance with the Decree of the Director General of Hubdat no 687 of 2002 is as follows

Table 5. Vehicle Waiting Time Standard Table

No.	Service Indicators	Unit	Assessment Standard (minutes)		
			Less	Medium	Good
1	Waiting time	minutes	>30	20 - 30	<20

Source: Decree of the Director General of Hubdat No. 687 of 2002

Based on the results of the survey that has been carried out and based on the calculation of the waiting time formula, the waiting time for Mojokerto-Batu public transportation is as follows:

$$\begin{aligned}
 \text{Vehicle Waiting Time} &= 0.5 \times \text{headway} \\
 &= 0.5 \times 106.2 \text{ minutes} \\
 &= 53.1 \text{ minutes}
 \end{aligned}$$

Or if displayed in a table of survey results, it will look like the following table:

Table 6. Waiting Time for Mojokerto - Batu Transportation

No.	Survey Date	Directions	Waiting Time
1	November 30, 2024	Mojokerto-Batu	00:52:53
		Batu-Mojokerto	00:53:05
2	December 1, 2024	Mojokerto-Batu	00:52:55
		Batu-Mojokerto	00:53:13
3	December 2, 2024	Mojokerto-Batu	00:53:25
		Batu-Mojokerto	00:53:10
4	December 3, 2024	Mojokerto-Batu	00:53:05
		Batu-Mojokerto	00:53:03
Average Waiting Time			00:53:06

Source: Analysis Result

Based on the survey data that has been done, the analysis results show that the average passenger waiting time on the Mojokerto-Batu route is 53 minutes 6 seconds or when converted to in minutes, the waiting time for Mojokerto-Batu transportation is 53.1 minutes. Thus according to the Decree of the Director General of Land Transportation number 687 of 2002 that the indicator of waiting time (lay over time) imposed by Mojokerto-Batu transportation is not good.

5. Load Factor for Mojokerto-Batu Transportation

The load factor of public transportation is the ratio of the number of public transportation passengers in the vehicle to the available capacity (Yang & Liu, 2022). Based on the Decree of the Director General of Hubdat number 687 of 2002, the standard load factor of public transportation is as follows:

Table 7. Performance Assessment Standard Table in Terms of Load Factor

No.	Service Indicators	Unit	Assessment Standard		
			Less	Medium	Good
1	Load Factor	%	>100	70 - 100	<70

Source: Decree of the Director General of Hubdat No. 687 of 2002

Based on the results of a static survey of public transportation that has been carried out, the average load factor obtained is as follows:

Table 8. Load Factor for Mojokerto - Batu Transportation

No.	Survey Date	Directions	Load Factor
1	November 30, 2024	Mojokerto-Batu	35,78%
		Batu-Mojokerto	33,26%
2	December 1, 2024	Mojokerto-Batu	33,68%
		Batu-Mojokerto	31,85%
3	December 2, 2024	Mojokerto-Batu	13,64%
		Batu-Mojokerto	14,34%
4	December 3, 2024	Mojokerto-Batu	14,34%
		Batu-Mojokerto	13,72%
Average Load Factor			23,83%

Source: Analysis Result

The results of static surveys that have been carried out show that there is a significant difference in the difference in the load factor value of Mojokerto - Batu transportation during holidays and weekdays (Sobari, 2023). On holidays the highest load factor of Mojokerto - Batu transportation is 35.78% while on weekdays the highest load factor value is 14.34% thus the average load factor of Mojokerto - Batu transportation is 23.83%. This shows that Mojokerto - Batu transportation is mostly used by passengers for tourist purposes considering Batu City is one of the tourist destinations in East Java (Abidin et al., 2024).

Based on the standards according to the Decree of the Director General of Hubdat number 687 of 2002, the load factor value of Mojokerto-Batu public transportation is in the good category. This is because the number of passengers can still be accommodated by the capacity of Mojokerto Batu transportation fleet vehicles (Hamid et al., 2022).

6. Mojokerto - Batu Transportation Frequency

Frequency is the number of vehicle trips in a given unit of time. Vehicle frequency is the number of vehicles passing the survey point per hour. Vehicle frequency data is obtained from a static survey at a predetermined point. The number of vehicles per hour is one of the performance indicators of a public transport service based on the Decree of the Director General of Hubdat No. 687 of 2002.

Table 9. Table of Standard Assessment of Public Transportation Performance in terms of Vehicle Frequency

No.	Service Indicators	Unit	Assessment Standard (kend/hr)		
			Less	Medium	Good
1	Vehicle frequency	Kend/hour	<4	4 - 6	>6

Source: Decree of the Director General of Hubdat No. 687 of 2002

Based on the survey results that have been carried out and based on the calculation of the frequency formula, the frequency of Mojokerto-Batu public transportation is as follows:

$$\begin{aligned}
 F &= 60 / \text{Headway (Kend/hr)} \\
 &= 60 / 106,2 \\
 &= 0.565 \text{ kend/hour}
 \end{aligned}$$

Or if displayed in a table of survey results, it will look like the following table:

Table 10. Frequency of Mojokerto - Batu Transportation

No.	Survey Date	Directions	Headway	Frequency
1	November 30, 2024	Mojokerto-Batu	01:45:45	105,75
		Batu-Mojokerto	01:46:10	106,16
2	December 1, 2024	Mojokerto-Batu	01:45:50	105,83
		Batu-Mojokerto	01:46:25	106,42
3	December 2, 2024	Mojokerto-Batu	01:46:50	106,83
		Batu-Mojokerto	01:46:20	106,3
4	December 3, 2024	Mojokerto-Batu	01:46:10	106,16
		Batu-Mojokerto	01:46:05	106,08
Average			01:46:12	106,2

Source: Analysis Result

From the survey that has been conducted, the results show that the Mojokerto-Batu route public transportation starts operating at 05.30 WIB until 16.30 WIB and the frequency of the public transport fleet is 0.565 vehicles / hour. This is still far when compared to the standards set by the Ministry of Transportation through the Decree of the Director General of Hubdat Number 687 of 2002. Therefore, the Mojokerto-Batu transportation service that has been operating at this time when viewed from the frequency indicator of the number of vehicles is still not good.

7. Mojokerto - Batu Transportation Travel Time

Mojokerto-Batu public transportation travel time data was obtained by conducting a dynamic survey / on bus survey. Travel time is the time required for a public transportation vehicle from the starting point of the route to the end point of the route. Mojokerto-Batu

transportation has a route length of 57.6 km. The following is the standard travel time published by the Ministry of Transportation:

Table 11. Standardized Assessment of Public Transportation Performance in terms of Travel Time

No.	Service Indicators	Unit	Assessment Standard (minutes/km)		
			Less	Medium	Good
1	Travel Time	Km/min	>12	6 - 12	<6

Source: Decree of the Director General of Hubdat No. 687 of 2002

The travel time of Mojokerto - Batu public transportation can be seen in the table below:

Table 12. Mojokerto - Batu Transportation Travel Time

No.	Survey Date	Directions	Location Point		minutes	Min. km
			Depar	Arrive		
1	November 30, 2024	Mojokerto-Batu	09:01	11:14	133	2,31
		Batu-Mojokerto	13:04	15:05	121	2,10
2	December 1, 2024	Mojokerto-Batu	09:05	11:18	133	2,31
		Batu-Mojokerto	13:04	15:17	133	2,31
3	December 2, 2024	Mojokerto-Batu	09:03	11:18	135	2,34
		Batu-Mojokerto	13:10	15:14	124	2,15
4	December 3, 2024	Mojokerto-Batu	09:05	11:21	136	2,36
		Batu-Mojokerto	13:08	15:20	132	2,29
Average Headway					130,88	2,27

Source: Analysis Result

Based on the results of dynamic surveys that have been carried out, travel time data is obtained. From the table above it is found that the travel time of Mojokerto-Batu transportation is in the good category in accordance with the Decree of the Director General of Hubdat number 687 of 2002. With a route mileage of 57.6 km, Mojokerto-Batu transportation can take an average of 2.27 minutes / km.

8. Mojokerto - Batu Transportation Speed

Data on the average speed of public transport can be obtained from dynamic surveys of public transport. Travel speed is the average speed of a public transport fleet, calculated from the start of the departure point to the end point of the route. With a distance of 57.6 km, the average speed standard in accordance with the Decree of the Director General of Hubdat no 687 of 2002 is as follows

Table 13. Public Transport Performance Assessment Standard Table in terms of Travel Speed

No.	Service Indicators	Unit	Rating Standard (km/h)		
			Less	Medium	Good
1	Travel Speed	km/h	<5	5 - 10	>10

Source: Decree of the Director General of Hubdat No. 687 of 2002

Mojokerto-Batu public transportation speed data when done in accordance with the calculation of the speed formula can be done as in the calculation below:

$$\begin{aligned}
 V &= \frac{S}{T} \\
 &= \frac{57,6 \text{ km}}{2,16 \text{ jam}} \\
 &= 26.6 \text{ km/h}
 \end{aligned}$$

Or if displayed in a table of survey results, it will look like the following table:

Table 14. Mojokerto - Batu transportation speed

No.	Survey Date	Directions	Location Point		Spee
			Depar	Arrive	
1	November 30, 2024	Mojokerto-Batu	09:01	11:14	25,95
		Batu-Mojokerto	13:04	15:05	28,51
2	December 1, 2024	Mojokerto-Batu	09:05	11:18	25,95
		Batu-Mojokerto	13:04	15:17	25,95
3	December 2, 2024	Mojokerto-Batu	09:03	11:18	25,60
		Batu-Mojokerto	13:10	15:14	27,96
4	December 3, 2024	Mojokerto-Batu	09:05	11:21	25,49
		Batu-Mojokerto	13:08	15:20	28,51
Average Headway					26,67

Source: Analysis Result

From the results of the dynamic survey that has been carried out. It is known that the average speed of Mojokerto-Batu transportation is 26.67 km/hour. When considering the standards set by the Ministry of Transportation through the Decree of the Director General of Land Transportation No. 687 of 2002, the average indicator of the speed of travel of Mojokerto-Batu transport is in the good category.

Conclusion

In accordance with the results of the analysis, the performance of Mojokerto-Batu transportation shows that: a) The average time between (headway) Mojokerto-Batu transportation is 01 hour 46 minutes 12 seconds, which falls into the poor category based on the Decree of the Director General of Land Transportation; b) The average waiting time for passengers is 53 minutes 6 seconds, which also falls into the poor category; c) The average load factor of Mojokerto-Batu transportation is 23.83%, which falls into the good category; d) The frequency of the Mojokerto-Batu transportation fleet is 0.565 vehicles/hour, which is considered poor; e) The travel time for Mojokerto-Batu transportation is 2.27 minutes/km, which is in the good category for a route mileage of 57.6 km; and f) The average speed of Mojokerto-Batu transportation is 26.67 km/h, which falls into the good category. The implications of these findings indicate that improvements are needed in the headway and frequency of the transportation service to reduce waiting times and increase service efficiency. To enhance public trust and satisfaction, the local government should consider increasing the frequency of the fleet and reducing the waiting time, potentially through better scheduling and fleet management. Future research could explore the potential for technological solutions such as real-time tracking and dynamic scheduling to optimize performance, as well as evaluate the impact of these improvements on passenger satisfaction and overall service quality.

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