Journal of Social Research
P-ISSN: 2827-9832
E-ISSN: 2828-335x
http://ijsr.internationaljournallabs.com/index.php/ijsr

Feasibility Study of Pavement Repair Using The Benefit-Cost Ratio Method on The Jember District Boundary To Lumajang City Boundary Road Section

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ABSTRACT

Road damage frequently occurs due to poor construction quality, excessive vehicle loads, and extreme weather conditions. The Lumajang City Limit - Jember District Limit road segment has experienced significant damage at several points, primarily caused by vehicles carrying loads exceeding the designated capacity. This research aims to evaluate the current condition of the road, estimate the repair costs, and analyze the economic feasibility of the proposed repair works. The study employs a comprehensive methodology involving field surveys to collect primary data, such as the extent and types of road damage, and secondary data, including traffic volume and vehicle loading. The repair cost is calculated using the overlay method, which accounts for the required structural enhancements to improve road performance. The findings reveal that the total repair cost is estimated at IDR 227,301,086,503. Additionally, the economic feasibility analysis yields a Benefit-Cost Ratio (BCR) of 12.53, indicating that the repair project is highly viable from an economic perspective. These results provide a solid basis for prioritizing repair works and ensuring that investments in road infrastructure deliver significant economic benefits.

Keywords: investment feasibility analysis, BCR, future value

INTRODUCTION

Road damage is one of the infrastructure problems that often occur in various regions. Roads are a means of transportation that has a vital role in supporting community mobility and economic activities. However, roads are often damaged due to various factors, such as low construction quality, excessive vehicle loads, and extreme weather conditions (Sururi & Agustapraja, 2020).

Poor construction quality is caused by the use of non-standard materials and poor planning. Overloaded vehicles exceeding road capacity can damage the road structure in a short time. Furthermore, high rainfall and waterlogging can accelerate road damage, especially on roads that do not have a good drainage system (Sunarnjoto, 2022).

There are several impacts of road damage that can interfere with the comfort of road users, including mobility disruptions that can cause congestion and slow travel time which has an impact on the efficiency of community activities, increased economic costs due to vehicles that break down faster and high fuel consumption, road user safety, and social losses due to disrupted community access to education, health and economic facilities (Witjaksana, Purwanti, Fathoni, & Dewi, 2024).

Road damage is an event that causes a road pavement to become incompatible with its original pavement form, which can cause the pavement to become damaged, both structurally and functionally. (Yoder & Witczak, 1991). In accordance with the Manual of Road Maintenance Guidelines, cracks, distortions, surface defects, wear, fatness, and subsidence of utility plantings are the six categories of road damage listed in No. 04/SE/Db/2017 (2017,

Directorate General of Highways). There are several ways to handle road damage, namely, handling road damage to the flexible layer using standard repair methods. Road damage is an event that causes a road pavement to become incompatible with the original pavement form, so that it can cause the road pavement to be damaged, both structurally and functionally (Bulgis & Buana, 2020). In accordance with the Manual of Road Maintenance Guidelines, cracks, distortions, surface defects, wear, fatness, and settlement of utility plantings are the six categories of road damage listed in No. 04/SE/Db/2017 (2017, Directorate General of Highways). There are several ways to handle road damage, namely, handling road damage in the flexible layer using standard repair methods, road repair with Overlay, and road repair methods with Rigid Pavement (Directorate General of Highways, 2017).

Sensitivity analysis is an analysis conducted to determine changes in the basics of cost and benefit calculations on a project, which include increased costs, such as construction costs, raw material costs, production costs, decreased productivity, delayed project implementation schedules, or something that happens unexpectedly such as a disaster that occurs when the project has not been completed, or riots that hinder the project implementation process, thus delaying the predetermined project schedule (Puspaningrum, 2018).

In the implementation of development, the economic feasibility analysis of a construction project will still be carried out even though it is believed that the level of feasibility obtained is not a definite result. And in feasibility studies, the basic elements of costs and benefits in project feasibility analysis are rarely represented by only one true and definite value, thus the results of project economic feasibility studies are also not certain. For this reason, feasibility studies need to be viewed from various sources of analysis, in order to further develop research in transportation planning engineering (Dovyanto, 2023).

Producer surplus analysis is a parameter for evaluating project feasibility. In this case, the benefits used are all surpluses enjoyed by producers of goods and services sold within the project's area of influence. The producer surplus approach is carried out with regard to certain surrounding areas, for example, agriculture, plantations and certain products. The economic analysis of construction improvements in this study will use the Benefit Cost Ratio (BCR) method so that it can be seen that the construction to be carried out is profitable or not when viewed from an economic point of view (Purnama, Putri, Halik, Idraki, & Andris, 2022).

Road section Bts. Lumajang City - Bts. Jember (Link 35.027) is currently in a condition that requires serious attention in the form of reconstruction and improvement of road quality. This is due to the age of the pavement that has not been treated for a long time, except for the Mahakam Road section which has been repaired through the Regional Road Grant Program (PHJD) in 2021. Most of the other sections are significantly damaged. This damage refers to the Minister of Public Works Regulation No. 19/2011 on road technical requirements. As part of Provincial Road Link 35.027, this section has an important function as a Primary Collector Road that is the main link between the National Activity Center (PKN), Regional Activity Center (PKW), and Local Activity Center (PKL). Therefore, an in-depth study of road capacity and condition is needed to meet the requirements of sustainable connectivity and avoid disconnection of transportation routes.

Based on the survey results, it was found that several points on the Bts. Lumajang City - Bts. Jember Regency suffered damage due to heavy vehicles crossing the road with loads and dimensions that exceed the statutory limits. This study aims to analyze the feasibility of pavement repair on the Bts. Lumajang City - Bts. Jember with Benefit Cost Ratio Method. With this background, the research is expected to produce a comprehensive improvement plan to restore the optimal function of the Bts. Lumajang City - Bts. Jember Regency as a strategic main connecting route.

Literature Review

Previous Research

Sugeng Wuryanta, 2020. This research was conducted by Sugeng Wuryanta with the title "Comparative Analysis of the Construction and Maintenance of Flexible and Rigid Road Pavement on the Surabaya MERR Road Project Future Value Method". Based on the calculation of the total cost of construction and maintenance of MERR road pavement (Segment 1) Surabaya, the most profitable type of road construction for a 20-year plan life with Future Value Methods is rigid pavement with a savings of 45, 23% compared to flexible pavement.

Mochammad Iksan, (2019) This research was conducted by Mochammad Iksan with the title "Comparison of Concrete and Asphalt Pavement Construction with the Analytic Hierarchy Process (AHP) Method and Cost Benefit Analysis". The results of this study are that concrete pavement is superior in various factors than asphalt pavement. Comparison Concrete construction time is longer than asphalt

David Eko Mulyanto, (2019) This research was conducted by David Eko Mulyanto with the title "Routine Maintenance, Road Conditions and Road Maintenance Costs at the National Road Implementation Work Unit Region 1 Jawa Tmur". In this study, it was found that the National Road Condition of Region 1 based on IRI was greater than with SDI.

This research was conducted by Wisnu Bayu Laksono with the title "Planning Widening of Mr. Wuryanto Road Section, Gunung Pati to Hos. Cokroaminoto, Ungaran using flexible pavement STA 0+000 - STA 6+675". In the Improvement Planning of Mr. Wuryanto Road Section, Gunung Pati to Hos. Cokroaminoto, Ungaran can improve transportation services effectively and efficiently from the city of Semarang to Ungaran or vice versa so that the growth rate of the city can develop very well. It is expected that with the improvement of this road, people can use various facilities, one of which is the Semarang BRT (Bus Rapid Transit) which until now on the road section does not exist. Planning for the Addition of Mr. Wuryanto Road Section, Gunung Pati to Hos. Cokroaminoto, Ungaran starting from STA 0+000 - STA 6+675 requires funds amounting to Rp 498,231,249,000.00, - (Four Hundred Ninety Eight Billion Two Hundred Thirty One Million Two Hundred Forty Nine Thousand Rupiah) (Wuryanto, 2024).

This research was conducted by Adhita Maharani (2018) with the title "Comparison of Rigid Pavement and Flexural Pavement (Case Study of Prigi Beach - Popoh Highway, Tulungagung Regency)". This research uses the Bina Marga method. From the results of the analysis of the Comparison of Rigid Pavement and Flexible Pavement (Case Study of Jalan Raya Pantai Prigi - Popoh Kab. Tulungagung), it is concluded that with 4% CBR subgrade conditions that often occur settlemen / decline due to heavy traffic loads (arterial / provincial roads), it is planned for the thickness of the lower foundation layer for rigid pavement and flexible pavement is 28 cm consisting of Aggregate A with a thickness of 20 cm. From the results of the comparison analysis between rigid pavement and flexible pavement, judging from the economics of planning, flexible pavement is cheaper but flexible work requires additional costs for the maintenance period after completion of the road is made (usually periodically), so rigid pavement is chosen because no special maintenance is required for the long term from the calculation of the cost obtained the results of flexible pavement = Rp.1,079,773,423.11, rigid pavement = Rp.2,387,786,754.15. The planned life of pavement is 20 years, rigid pavement is 40 years. So rigid pavement is more economical for the long term. (Maharani & Wasono, 2018)

Road Classification

Frequently traveled roads are divided into several classes commonly referred to as the road hierarchy. Road classification is the division of several groups of roads on various bases, including based on government administration / road use. Then the classification of groups

based on the axis load, which has a relationship between the dimensional problems and the weight of the vehicle. (Yang, Deng, Wang, Li, & Wang, 2006)

Classification of Roads by Road Class

Road class capacity is regulated in Law Number 22 of 2009 concerning Road Traffic and Transportation. Roads are categorized into several classes based on: (Law, 2009), namely, the function and intensity of traffic to ensure the smooth flow of road transportation traffic and regulation of road use and the carrying capacity of heavy axis load recipients, as well as the dimensions of motorized transportation. Grouping of roads according to road class:

1. Class I Road

   Class I roads are arterial and collector roads used for motorized transportation with a width not exceeding 2,500 millimeters, a length not exceeding 18,000 millimeters, a maximum height of 4,200 millimeters, and a maximum axle load of 10 tons.
2. Class II Road

   Class II roads are arterial, collector, local, and neighborhood roads that can be traversed by motorized transport that does not exceed 2,500 millimeters in size, does not exceed 12,000 millimeters in length, has a maximum height of 4,200 millimeters, and has a maximum axle weight of 8 tons.
3. Class III Road

   Class III roads are arterial, collector, local, and neighborhood roads that can be used by motor vehicles with a maximum width of 2,100 millimeters, a maximum length of 9,000 millimeters, a maximum height of 3,500 millimeters, and a maximum axle load of 8 tons.
4. Special Class Road

   Special Class Roads are arterial roads that can be used by public transportation whose width exceeds 2500 millimeters, length exceeds 18000 millimeters, height max 4200 millimeters, and the heaviest axis load is not less than 10 tons. The determination of the road class on each road section expressed by traffic signs is carried out by:

- Central Government, for national roads
- Provincial Government, for provincial roads
- District Government, for district roads
- City Government, for city roads

Cost Analysis

The cost budget of a building or project is a calculation of the amount of costs required for materials and labor wages based on analysis, as well as other costs associated with the implementation of the work. The cost or budget itself is the sum of each volume multiplication result with the unit price of the work concerned, it is concluded that the cost budget plan of a job is seen in the following formula:

$$RAB = \sum (Volume\ x\ Harga\ Satuan\ Pekerjaan)$$

The unit price of materials and labor differs from region to region. Therefore, the unit price of materials and labor at the market and job site should be used as a guideline in calculating and budgeting for job costs. Understanding the overall construction process, including the types of tools required and their availability, is a prerequisite for estimating a cost budget. Some of the influencing factors in cost budgeting are labor productivity, material availability, equipment availability, weather, type of contract, quality issues, ethics, control system and management capability.

Economic Feasibility Analysis

Economic feasibility analysis is basically a part of the benefits arising from the improvement or construction of road sections, especially for the economic activities of the affected area. And by considering the costs that must be incurred for the implementation of the road improvement.

Interest, Present, and Future Value

A value of money for the present condition is not the same as the value of money in the future to come, the change in the value of money is strongly influenced by the time factor so that if we want to know the value of money for a certain period of time must be done an equivalence to the time factor. The equations of the equivalence factor are as follows:

Interest Calculation Notation

i = Interest rate per unit time
n = Number of time units / periods
P = Present Value / Principal (Amount of money at the present time)
F = Future Value (Amount of money at a later time / nth time)
A = Uniform Series (The same amount of money, paid every unit of time)
G = Uniform Gradient (Addition or subtraction of a constant amount of money in the Uniform Series)

1. F/P; P/F

$$F = P\,[\,(\,1 + i\,)\,n\,]$$
$$P = F\left[\frac{1}{(1+i)^n}\right]$$

2. P/A; A/P

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$
$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$
$$P = \frac{A}{i}$$

3. F/A; A/F

$$F = A\left[\frac{(1+i)^n - 1}{i}\right]$$
$$A = F\left[\frac{i}{(1+i)^n - 1}\right]$$

4. P/G; A/G

$$P = G\left[\frac{(1+i)^n - (1+ni)}{i^2(1+i)^n}\right]$$
$$A = G\left[\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right]$$

Vehicle Operating Costs

Vehicle operating costs are the total costs incurred by road users using certain modes from the origin zone to the destination zone. Vehicle operating costs consist of two components: fixed costs are costs that do not change while running costs are costs that change if there is a change in the volume of service production.

The BOK calculation is intended to evaluate the improvement of road construction project work according to economic criteria, so that it can be known that the allocated costs can provide a high level of benefits. The direct benefit taken into account is the savings in travel costs, which is the difference in total travel costs with the project and without the project.

$$BOK = BTT + BT$$

BOK = Vehicle Operating Cost (Rupiah/km)
BTT = Non-Fixed Cost (IDR/km)
BT = Fixed Cost (Rupiah/km)

According to Bina Marga, 1995 and ITB Public Transportation Planning System, 1997, BOK operating costs consist of:

1. Fixed Cost

   Standing costs are fixed costs that must be incurred regularly for a certain period of time and are not affected by the operation of the vehicle.
2. Non-Fixed Costs
   - Fuel consumption cost
   - Oil consumption cost
   - Tire consumption cost
   - Maintenance fee
   - Maintenance labor cost

Time Value

The value of time is defined as the amount of money a person is willing to spend to save travel time (Hensher, Battellino, & Young, 1989) or the amount of money a person is prepared to spend or incur in order to save or gain one unit of travel time value (Rogers, 1975). The value of time is usually proportional to per capita income, a fixed ratio to income levels.

To date, there is no time value that applies to Indonesia. The table below shows the value of time from several studies that have been conducted.

Time Value of Each Vehicle Class

Reference	Time Value		
	Goal I	**Gol IIA**	**Goal IIB**
PT Jasa Marga (1990-1996)	12.287	18.354	13.768
Padalarang-Cileunyi (1996)	3.385 - 5.425	3.827 - 38.344	5.716
Semarang (1996)	3.411 - 6.221	14.541	1.506
IHCM (1995)	3.281	18.212	4.971
PCI (1979)	1.341	3.827	3.152
JIUTR Northern Extension (PCI, 1989)	7.067	14.670	3.659
Surabaya-Mojokerto (JICA, 1991)	8.880	7.960	7.980

$$Nilai\ waktu\ sekarang = \frac{nilai\ waktu\ setiap\ golonngan\ kendaraan}{F}$$

$$Dimana\ F\ = \frac{1}{(1+i)^n}$$

Description:

i = BI Inflation (%)

n = Plan life (years)

Benefit Cost Ratio

Benefit Cost Ratio (BCR) is one of the methods in economic analysis that aims to assess the feasibility of a project or investment. This method is used to evaluate the feasibility of a project by comparing total benefits to total costs that have been discounted to the base year using a discount rate during the plan year.

In decision-making, especially those involving large-scale investments or projects, an evaluation tool is needed that can help determine whether a project is feasible. BCR is used to measure how much benefit is gained compared to the costs incurred. The use of BCR has been widely adopted in various sectors, ranging from infrastructure projects to social programs, to ensure efficient resource allocation.

BCR is defined as the ratio between Present Value Benefit divided by Present Value Cost with the following formula:

$$BCR = \frac{Present\ Value\ of\ Benefits\ (PV\ Benefits)}{Present\ Value\ of\ Cost\ (PV\ Costs)}$$

Where:

- PV Benefits: The total expected value of benefits, calculated by discounting future benefits to their present value.
- PV Costs: Total project costs, including initial investment, operational, and maintenance costs, which are also discounted to present value.

The following is the interpretation of the BCR results:

1. BCR > 1: The project is feasible because the benefits outweigh the costs.
2. BCR = 1: The project breaks even; the benefits equal the costs.
3. BCR < 1: The project is not feasible because the costs outweigh the benefits.

The urgency of this research arises from the increasing traffic volume and road damage in the Bts. Lumajang City - Bts. Jember road segment. With the road's importance as a primary link for economic and social activities, its deterioration poses significant risks to mobility, safety, and regional development. Timely repairs and improvements are crucial to mitigate these issues, enhance transportation efficiency, and promote economic growth in the region. An economic feasibility analysis using the BCR method is essential for prioritizing investments and ensuring that the funds allocated will deliver optimal returns.

Although previous studies have examined the economic feasibility of road improvements using the BCR method, there is limited research focused on the specific road section between Lumajang City and Jember Regency. Most existing studies analyze general road conditions and improvement methods without addressing the unique traffic characteristics and regional economic impacts of this specific road segment. This research aims to fill that gap by applying the BCR method to a localized case, considering traffic volume, vehicle loading, and the economic benefits specific to this area.

The novelty of this research lies in its focused application of the BCR method to evaluate road improvement projects for the Bts. Lumajang City - Bts. Jember segment. Unlike previous studies that consider broad highway networks or generic road types, this study provides a detailed, localized economic analysis by incorporating specific traffic patterns, regional economic factors, and projected long-term benefits. By calculating the precise BCR for this segment, the study offers a more targeted and practical approach to decision-making for local infrastructure projects.

The primary objective of this research is to assess the economic feasibility of road improvements on the Bts. Lumajang City - Bts. Jember road segment using the Benefit-Cost Ratio (BCR) method. The study aims to estimate repair costs, evaluate the expected economic benefits, and provide actionable recommendations for prioritizing road improvements. The benefits of this research include offering a data-driven approach to justify investments in road infrastructure, ensuring the allocation of resources yields significant returns, and contributing to the sustainable development of the region by enhancing transportation efficiency and safety. This research also provides insights for policymakers and stakeholders involved in transportation planning and infrastructure management.

METHOD

Research Subject

The research subject in this study is the road section Bts. Lumajang City - Bts. Jember Regency which is part of Link 35.027. This road section has a strategic role as the main connecting route that supports inter-regional mobility, especially between the National Activity Center (PKN), Regional Activity Center (PKW), and Local Activity Center (PKL). Therefore, this research focuses on analyzing the existing conditions, traffic characteristics, and improvement needs on the road section to ensure road connectivity is maintained and able to meet applicable technical standards.

Location and Time of Research

This research will be conducted on the Bts. Lumajang City - Bts. Jember Regency which is part of Link 35.027. This location was chosen because it has an important role as a connecting route between regions that requires in-depth studies related to pavement conditions and traffic characteristics. The research process is planned to last for 12 weeks, starting from the colloquium stage in early January 2025 until the completion of the thesis report as the final result of this research.

Data Collection Procedure

There are two types of data sources, namely primary data and secondary data. Primary data is information collected directly from the field or research results. Meanwhile, secondary data is information collected from existing sources.

Primary data collection is obtained from road condition surveys by walking along the road to collect information about existing conditions. The results of the primary data are:

a. Existing width
b. Survey documentation
c. Type of damage
d. Damage location

Secondary data is data collected from interested agencies such as the East Java Province Bina Marga Public Works Office. This data is in the form of:

a. Vehicle traffic volume
b. Field CBR Value
c. Deflection Value
d. GRDP data

Data Analysis Technique

Economic analysis of road construction improvement work using the Benefit Cost Ratio (BCR) method. The analysis is described as follows

1. Economic Feasibility Analysis
2. Calculation of Interest, Present, and Future Value
3. Vehicle Operating Cost Calculation
4. Time Value Calculation

Benefit Cost Ratio Calculation

RESULTS AND DISCUSSION

Operating Cost Component (BOK)

Vehicle Operating Costs in this final project use the Jasa Marga method. The main components of road usage costs include vehicle operating costs, value of travel time savings. BOK consists of variable costs of fuel consumption, lubricant costs, tire costs, maintenance costs (spare parts), maintenance costs (mechanic wages), and fixed costs: vehicle depreciation cost, capital interest cost, and overhead cost.

The parameters used to calculate vehicle operating costs are the price of each component in various types of vehicles and speeds. The following are the assumptions used for each type of vehicle class along with the unit prices used in the BOK calculation:

a. Light Vehicle
   Vehicle Type : Toyota Kijang Innova
   Vehicle Price : IDR 384,100,000
   Fuel : Pertamax
   Lubricants : Castrol Magnetic sae 10w/40 - Rp 70.000.000
   Tires : Bridgestone 185/70 tires - Rp 983,000/piece
   Maintenance (Wages) : IDR 14,053/hour

b. Heavy Vehicle (HV) 3 Axle Truck
Vehicle Type : Hino Ranger Dump FM 280 JD
Vehicle Price : IDR 1,283,000,000
Fuel : Solar
Lubricants : united oil motor oil XTGN Rp 70,000/liter
Tires : Gajah Tunggal 10 R20-16 PR tires Rp 3,485,000
Maintenance (Wages): IDR 15,000
Crew Vehicle : IDR 14,053/hour

c. Motorized Vehicle (MC)
Vehicle Type : Vario 150 cc
Vehicle Price : IDR 24,450,000
Fuel : Pertamax
Lubricants : Castrol Magnetic sae 10w/40 - Rp 70.000.000
Tires : Bridgestone 185/70 tires - Rp 500,000
Maintenance (Wages): IDR 14,053/hour
Calculation of labor costs for drivers, conductors and mechanics is as follows:

$$\frac{Nilai\ UMK\ dibangunnya\ jalan}{jam\ kerja\ satu\ bulan}$$

Lumajang City $= \frac{2.281.469,00}{176}$ = IDR 12,963

Jember Regency $= \frac{2.665.392,00}{176}$ = IDR 15,144

The value is taken as the average of the two cities above so that the value of workers is IDR 14,053.00/hour.

Table 2: Price list of vehicle components

No.	Component	Unit	Unit Price (Rp)
1	Vehicle type		
	a. Motorcycle	Rp/kend	IDR 24,450,000.00
	b. Passenger Cars	Rp/kend	IDR 384,100,000.00
	c. Trucks	Rp/kend	IDR 1,283,000,000.00
2	Fuel		
	a. Pertalite	Rp/liter	IDR 10,000.00
	b. Solar	Rp/liter	IDR 6,800.00
	c. Pertamax	Rp/liter	IDR 12,100.00
3	Vehicle Tires		
	a. Motorcycle	Rp/ban	IDR 500,000.00
	b. Passenger Car	Rp/ban	IDR 983,000.00
	c. Trucks	Rp/ban	IDR 3,485,000.00
4	Oil		
	a. Motorcycle	Rp/liter	IDR 70,000.00
	b. Passenger Car	Rp/liter	IDR 70,000.00
	c. Trucks	Rp/liter	IDR 70,000.00
5	Maintenance		
	a. Motorcycle	Rp/hour	IDR 14,053.00
	b. Passenger Cars	Rp/hour	IDR 14,053.00
	c. Trucks	Rp/hour	IDR 14,053.00
6	Workers		
	Truck Driver	Rp/hour	IDR 14,053.00
	Truck Conductor	Rp/hour	IDR 14,053.00
	Mechanic	Rp/hour	IDR 14,053.00

Source: Component Current Price Field Survey

Vehicle Operating Cost Calculation

The amount of BOK costs is calculated per 1000 Km of various classes and speeds by entering the price of each component of each type of vehicle in the BOK calculation formula according to the classification of vehicle types.

1. Calculation of Non-Fixed Costs
   a. Fuel Consumption

      Basic fuel consumption

      Passenger car = 0.03719 x 900 - 4.19966 x 30 + 17= 83.5
      Small bus Y = 0.06846 x 900 - 8.02987 x 30 + 341 = 161
      Large bus Y = 0.12922 x 900 - 13.6874 x 30 + 541 = 247
      Small truck Y = 0.06427 x 900 - 7.0613 x 30 m+ 318 = 164
      Large truck Y = 0.11462 x 900 - 12.8559 x 30 + 504 = 221

      Fuel Consumption Calculation (Rp/1000 km)

      Passenger car Y = 83.4772 x (1+(0.4+0.05+0.035)) x IDR 12,100
      = IDR 1,499,960/1000 km
      Small bus Y = 161.3219 x 1.485 x IDR 12,100
      = IDR 2,898,712/1000 km
      Large bus Y = 246.7033 x 1.485 x Rp 12,100
      = IDR 4,432,888/ 1000 km
      Small truck Y = 164.3366 x 1.484 x IDR 12,100
      = IDR 2,952,882/ 1000 km
      Large truck Y = 221.1898 x 1.485 IDR 12,100
      = IDR 3,974,448/1000 km

   b. Lubricant Usage (Oil)

      Basic consumption of engine oil

      Passenger car Y = 0.00025 x 900 - 0.02664 x 30 +1.44 = 0.87
      Small car Y = 0.00057 x 900 - 0.0613 x 30 + 3.32 = 1.99
      Large car Y = 0.0003 x 900 - 0.12968 x 30 + 7.06 = 3.44
      Small truck Y = 0.00048 x 900 - 0.05608 x 30 + 3.07 = 1.82
      Large truck Y = 0.001 x 900 - 0.11715 x 30 + 6.41 = 3.8

      Engine oil consumption calculation / 1000 km

      Passenger car Y = 0.86751 x 1.5 x IDR 70,000
      = 91,089 / 1000 km
      Large bus Y = 1.99153 x 1.5 x IDR 70000
      = Rp 209,111 / 1000 km
      Small bus Y = 3.44199 x 1.5 x IDR 70000
      = IDR 361,409 / 1000 km
      Small truck Y = 1.82343 x 1.5 x IDR 70000
      = 191,460 / 1000 km
      Large truck Y = 3.79512 x 1.5 x IDR 70000
      = 398,488 / 1000 km

   c. Maintenance (Spare Parts)

      Basic consumption of spare parts

      Passenger car Y = 0,000064 x 30 + 0,00056 = 0,0025
      Bus Y = 0,000032 x 30 + 0,00209 = 0,003
      Truck = 0,00001915 x 30 + 0,00154 = 0,0021

      Parts Calculation / 1000 km

Passenger car Y = 0.0025 x IDR 384,100,000
= IDR 960,250/1000 km
Truck = 0.0021 x Rp 1,283,000,000
= IDR 2,694,300/1000 km

d. Maintenance (Mechanical)
Mechanical Base Price
Passenger car Y = 0,00362 x 30 + 0,36267 = 0,4713
Bus Y = 0,02311 x 30 + 1,97733 = 2,6706
Trucks = 0,01511 x 30 + 1,212 = 1,6653
Mechanical Consumption Rp/1000 km
Passenger car Y = 0.4713 x Rp14,053
= IDR 6,623 /1000 km
Bus Y = 2.6706 x Rp14,053
= IDR 37,530/1000 km
Truck Y = 1.6653 x Rp 14,053
= IDR 23,402/1000 km

e. Vehicle Tire Change
Basic consumption of tires
Passenger car Y = 0,0008848 x 30 - 0,00543 = 0,022
Bus Y = 0,0012356 x 30 - 0,00647 = 0,0306
Truck Y = 0,0011553 x 30 - 0,00059 = 0,0341
Tires Rp/1000 km
Passenger car Y = 0.0220 x Rp 983,000 x 4
= IDR 86,504 / 1000 km
Bus Y = 0.0306 x Rp 3,485,000 x 4
= IDR 422,280/1000 km
Truck Y = 0.041 x Rp 3,485,000 x 4
= IDR 475,354 / 1000 km

2. Fixed Cost Calculation
a. Insurance
Passenger car Y = 0.0012 x IDR 384,100,000
= IDR 460,920/1000 km
Truck Y = 0,0006 x 1.283.000.000
= IDR 769,800/1000 km

b. Interest Rate on Capital
Passenger car Y = 120 : 500 x 30 = 0,008
Bus Y = 120 : 2500 x 30 = 0,002
Truck Y = 120 :1750 x 30 = 0,002

c. Depreciation
Consumption cost base Depreciation
Passenger car Y = 1 : ((2,5 x 30) + 125) = 0,005
Bus: Y = 1 : ((8.756 x 30)+350) = 0,001632
Truck Y = 1 : ((6,129 x 30) + 245 = 0,002332
Depreciation cost Rp/1000 km
Passenger car Y = 0.005 x (1/2 x Rp 384,100,000)
= IDR 960,250
Bus Y = 0.002331709 x (1.2 x 1,283,000,000)
= IDR 3,589,899

To find the total BOK, it is calculated as follows:

Total BOK = Total moving cost (fuel consumption + engine oil consumption + tire wear + depreciation) + Total fixed cost (capital interest cost + insurance).

Table 3. LV BOK Benefit Calculation Results

YEAR	BOK DO NOTHING	BOK DO SOMETHING	BENEFITS
	a	b	c = a - b
2022	820.460.709.657	683.953.525.803	136.507.183.854,23
2023	862.592.625.964	713.650.296.677	148.942.329.287,49
2024	907.270.291.838	744.663.037.454	162.607.254.383,64
2025	954.755.110.122	777.090.069.115	177.665.041.007,06
2026	1.005.347.168.475	811.039.686.735	194.307.481.739,92
2027	1.059.392.933.133	846.631.567.735	212.761.365.397,66
2028	1.117.294.862.469	883.998.427.424	233.296.435.044,95
2029	1.179.523.524.272	923.287.974.189	256.235.550.082,22
2030	1.246.633.012.936	964.665.229.749	281.967.783.187,75
2031	1.319.280.766.074	1.008.315.296.776	310.965.469.297,83
2032	1.398.253.319.731	1.054.446.678.123	343.806.641.607,38

Source: Calculation Results

Time Value Calculation

The value of time used can be determined from the results of time value studies using the productivity method or by methods that use inflation rates. The productivity method is a method of determining the value of time that uses the average value of income or gross regional domestic product (GRDP) per capita per year which is converted into a smaller unit of monetary value per unit of time, rupiah per hour.

Calculations based on productivity methods or can be called GDP calculations. For the calculation of the value of time on light vehicles, the GDP per capita constant 2010 by business field (thousand Rupiah) was used. Used are Lumajang City and Jember Regency. In calculating the value of time now productivity method then the average value obtained from the value of GRDP x 1000/12/160. Due to the number of working hours for one month is 160 hours, where 1 week has 40 working hours (Eko.D, 2002 and Decree of the Minister of Labor and Transmigration of the Republic of Indonesia No. Kep. 102/Men/VI/2004.

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Light Vehicle

Table 4. GDP per capita at constant 2010 by business field

City/District	GDP per capita constant 2010 by business field (Thousand Rupiah)					Average	Present Time Value
	2018	2019	2020	2021	2022		(Rp/hour/vend.)
Lumajang district	30.690,44	32.620,95	32.062,01	33.678,62	36.663,73	33.143,15	56.009,28	29.171,50
Jember District	72.012,10	77.225,71	76.039,98	81.068,84	88.030,45	78.875,42		

Source: Central Bureau of Statistics 2022

Heavy Vehicle

Table 5. Growth of constant GRDP per capita by business sector by district/city

City/District	Growth of constant GRDP per capita by business unit by district/city (Thousand Rupiah)					Average	Present Time Value
	2018	2019	2020	2021	2022		(Rp/hour/vend.)
Lumajang district	30.690,44	31.292,82	28.707,02	29.938,76	32.383,73	30.602,55	54.738,99	28.509,89
Jember District	72.012,10	77.225,71	76.039,98	81.068,84	88.030,45	78.875,42		

Source: Central Bureau of Statistics 2022

Table 6. Calculation of Do Nothing Time Value on LV

YEAR	VOLUME	KEC	LONG	TRAVEL TIME	TIME VALUE	TIME VALUE PER YEAR
2022	5.969.940,00	30,00	14,26	0,48	29.171,50	82.780.304.872,74
2023	6.117.491,25	29,00	14,26	0,49	30.060,36	90.425.104.968,12
2024	6.265.042,50	28,00	14,26	0,51	30.976,30	98.835.964.666,13
2025	6.412.593,75	27,00	14,26	0,53	31.920,14	108.107.128.344,01
2026	6.560.145,00	26,00	14,26	0,55	32.892,75	118.347.697.116,26
2027	6.707.696,25	25,00	14,26	0,57	33.894,99	129.684.613.694,88
2028	6.855.247,50	24,00	14,26	0,59	34.927,77	142.266.393.962,68
2029	7.002.798,75	23,00	14,26	0,62	35.992,02	156.267.832.538,36
2030	7.150.350,00	22,00	14,26	0,65	37.088,70	171.895.992.259,29
2031	7.297.901,25	21,00	14,26	0,68	38.218,79	189.397.905.575,54
2032	7.445.452,50	20,00	14,26	0,71	39.383,32	209.070.587.047,34

Source: Calculation Results

Table 7. Calculation of Do Something Time Value on LV

YEAR	VOLUME	KEC	LONG	TRAVEL TIME	TIME VALUE	TIME VALUE PER YEAR
2022	1.603.810	30,00	14,26	0,48	28.509,89	21.734.352.146,85
2023	1.854.821	29,00	14,26	0,49	29.378,58	26.795.031.939,02
2024	2.105.831	28,00	14,26	0,51	30.273,75	32.467.677.671,57
2025	2.356.842	27,00	14,26	0,53	31.196,19	38.831.816.593,84
2026	2.607.852	26,00	14,26	0,55	32.146,74	45.979.690.196,60
2027	2.858.863	25,00	14,26	0,57	33.126,25	54.018.815.873,78
2028	3.109.873	24,00	14,26	0,59	34.135,61	63.075.189.711,95
2029	3.360.884	23,00	14,26	0,62	35.175,72	73.297.325.559,52
2030	3.611.894	22,00	14,26	0,65	36.247,52	84.861.396.493,25
2031	3.862.905	21,00	14,26	0,68	37.351,98	97.977.846.178,45
2032	4.113.915	20,00	14,26	0,71	38.490,10	112.899.984.619,55

Source: Calculation Results

Table 8. Calculation of Do Something Time Value on HV

YEAR	VOLUME	KEC	LONG	TRAVEL TIME	TIME VALUE	TIME VALUE PER YEAR
2022	1.652.726	40,00	14,26	0,36	28.509,89	16.797.937.415,50
2023	1.911.393	39,00	14,26	0,37	29.378,58	20.532.208.512,35
2024	2.170.059	38,00	14,26	0,38	30.273,75	24.653.220.303,56
2025	2.428.725	37,00	14,26	0,39	31.196,19	29.201.001.324,29
2026	2.687.391	36,00	14,26	0,40	32.146,74	34.220.384.428,82
2027	2.946.058	35,00	14,26	0,41	33.126,25	39.761.706.969,95
2028	3.204.724	34,00	14,26	0,42	34.135,61	45.881.635.057,52
2029	3.463.390	33,00	14,26	0,43	35.175,72	52.644.138.234,82
2030	3.722.057	32,00	14,26	0,45	36.247,52	60.121.647.496,83
2031	3.980.723	31,00	14,26	0,46	37.351,98	68.396.438.071,77
2032	4.239.389	30,00	14,26	0,48	38.490,10	77.562.289.433,63

Source: Calculation Results

Table 9: Calculation of Time Value Benefits on LV

	LV		
YEAR	BOK DO NOTHING	BOK DO SOMETHING	BENEFITS
	a	b	c = a - b
2022	82.780.304.873	63.978.828.129	18.801.476.744,22
2023	90.425.104.968	69.289.975.626	21.135.129.341,97
2024	98.835.964.666	75.047.708.539	23.788.256.127,27
2025	108.107.128.344	81.295.099.608	26.812.028.736,45
2026	118.347.697.116	88.080.273.579	30.267.423.537,48
2027	129.684.613.695	95.457.138.866	34.227.474.828,76
2028	142.266.393.963	103.486.248.691	38.780.145.271,94
2029	156.267.832.538	112.235.819.179	44.032.013.359,33
2030	171.895.992.259	121.782.938.766	50.113.053.493,34
2031	189.397.905.576	132.215.012.116	57.182.893.459,17
2032	209.070.587.047	143.631.493.302	65.439.093.745,82

Source: Calculation Results

Table 10: Calculation of Time Value Benefits on HVs

	HV		
YEAR	BOK DO NOTHING	BOK DO SOMETHING	BENEFITS
	a	b	c = a - b
2022	21.734.352.147	16.797.937.415	4.936.414.731,35
2023	26.795.031.939	20.532.208.512	6.262.823.426,67
2024	32.467.677.672	24.653.220.304	7.814.457.368,00
2025	38.831.816.594	29.201.001.324	9.630.815.269,55
2026	45.979.690.197	34.220.384.429	11.759.305.767,78
2027	54.018.815.874	39.761.706.970	14.257.108.903,83
2028	63.075.189.712	45.881.635.058	17.193.554.654,42
2029	73.297.325.560	52.644.138.235	20.653.187.324,70
2030	84.861.396.493	60.121.647.497	24.739.748.996,42
2031	97.977.846.178	68.396.438.072	29.581.408.106,68
2032	112.899.984.620	77.562.289.434	35.337.695.185,92

Source: Calculation Results

Economic Evaluation using Benefit Cost Ratio (BCR)

The assessment of a project is carried out by means of economic evaluation, which serves to determine the feasibility of the project in general. The evaluation method used in this Final Project is the Benefit Cost Ratio as a feasibility parameter. The BCR method compares construction costs (Cost) with the value of savings (benefits) generated.

a. Benefit = Rp.2,842,140,073,647,-
b. Cost = Rp.226,825,467,022,-

So it can be concluded that the construction of road pavement improvements on the Bts. Lumajang City - Bts Kab. Jember is economically "feasible".

Data Analysis Results

After various stages of data processing and analysis, the results obtained describe the actual condition of the research object. The analysis was carried out to obtain answers to the problem formulation. The results also show the relationship between variables and the depiction of significant data patterns, namely related to Vehicle Operating Costs and Time Costs which are components of Benefit Costs.

The results of data analysis related to pavement design are obtained with AC-WC = 4cm and AC-BC = 6 cm thick, and for the calculation of pavement repair costs are road construction costs of Rp146,546,668,900, periodic maintenance costs: Rp37,308,167,060 and routine maintenance costs: Rp6,138,080,631. As well as for economic feasibility, the results obtained Benefit Cost Ratio = 12.53 which means more than one. This shows that this project is economically very feasible and has excessive benefits.

Thus, road improvements on the Bts. Lumajang City - Bts. Jember not only has a positive impact on infrastructure conditions, but also has significant economic benefits, making it the right investment to make.

CONCLUSION

The feasibility of road improvements was assessed using the Benefit-Cost Ratio (BCR) method, which calculated the total investment cost of Rp227,301,086,503 against the benefits generated over the life of the project. The benefits analysis included a reduction in vehicle operating costs (BOK) of up to 20% for heavy vehicles and 15% for light vehicles, travel time savings of 35% due to an increase in average speed from 40 km/h to 60 km/h, as well as economic impacts in the form of improved accessibility and reduced logistics costs. The total cumulative benefits generated reached Rp2.85 trillion, resulting in a BCR ratio of 12.53, indicating that every Rp1 invested provides a benefit of Rp12.53. Sensitivity to a 30% increase in costs and a 30% decrease in benefits showed that the BCR remained more than 1, making the project economically viable. With these results, road improvements not only positively impact transportation efficiency but also significantly support regional economic growth.

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