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Comparison of Concrete and Asphalt Pavements: Cost and Time Analysis on The Bendung-Bantengan Road Section In Mojokerto District

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KEYWORDS
cost, concrete pavement, asphalt pavement, road pavement, mojokerto

ABSTRACT
Road infrastructure development plays a crucial role in supporting connectivity, mobility, and economic growth. This study analyzes and compares the cost and time aspects of concrete and asphalt pavement construction on the Bendung-Bantengan road segment in Mojokerto Regency. The methods applied include an analysis of average daily traffic (ADT) data, soil California Bearing Ratio (CBR) tests, and regional topography assessments. The asphalt pavement design adheres to the 2017 Manual for Pavement Design (MDPJ), while the concrete pavement design follows the Pd T-14-2003 guidelines. The findings reveal that concrete pavement with a thickness of 25 cm incurs a total cost of IDR 2.49 billion, which is more economical in the long term compared to asphalt pavement costing IDR 3.36 billion. In terms of construction time, concrete pavement requires a shorter duration of 108 days, whereas asphalt pavement takes 120 days to complete. Concrete pavement also demonstrates superior durability and resistance to heavy traffic loads, making it an ideal choice for areas with high traffic intensity and stable soil conditions. Conversely, asphalt pavement, despite its lower initial cost and faster implementation, demands more frequent maintenance, resulting in higher long-term expenses. This study underscores the importance of selecting the appropriate pavement type based on traffic conditions, budget constraints, and project timelines. The findings contribute to more efficient and sustainable road infrastructure planning, offering valuable insights for policymakers and engineers tasked with improving regional connectivity and infrastructure resilience.

Introduction

Road infrastructure development plays an important role in supporting economic growth and improving connectivity between regions (McKinsey, 2020). Good roads enable the distribution of goods and human mobility to run smoothly, thereby accelerating economic growth and equity in various regions (MDPI, 2021). Mojokerto Regency, which has a diverse topography ranging from lowlands to hills, is one of the areas that requires improved road infrastructure to support the economic and social activities of the community (Ministry of Public Works, 2017).

Pavement is a crucial part of transportation infrastructure development. There are two types of pavement that are commonly used, namely rigid pavement and flexible pavement. Rigid pavement uses cement concrete as the main material, while flexible pavement uses asphalt (Ikons.id, 2020; Mutuutamageoteknik.co.id, 2022). The choice of pavement type is strongly influenced by factors such as traffic, soil conditions, climate, and material availability (Hardiyatmo, 2015).

In the Bendung - Bantengan road section of Mojokerto Regency, there is a significant increase in traffic volume, so a study is needed to determine the most suitable and economical pavement type (Dewi, 2023). This road is the main access for residents and transportation of goods from rural areas to the city center, so road durability is a major concern in development (Sewaalatberat.co.id, 2020).

Comparative studies between concrete and asphalt pavements have been conducted in many areas, such as those conducted on the Makassar City Middle Ring Road project (Rahman et al., 2025) and Babat - Batas Jombang Road in Lamongan (Aditiya & Siswoyo, 2020). The results showed that although concrete pavement has a higher initial cost, it has a longer service life and lower maintenance costs than asphalt pavement (Lelepadang, S., Nuhun, R., Nasrul, N., & Ahmad, 2020).

In Mojokerto district, the varied geography demands an adaptive construction approach. Rigid pavements are often used in areas with heavy traffic and high rainfall because they are more resistant to deformation and cracking under excessive loads (Department of Housing and Regional Infrastructure, 2003). In contrast, flexible pavements are more suitable for areas with moderate traffic and are more economical for initial construction (Ministry of Public Works, 2013).

Research conducted by Asidin (2021) and Assa et al. (2022) show that flexible pavements tend to be easier and faster to implement, thus reducing project implementation time and traffic disruption. However, in the long run, they require more frequent maintenance than rigid pavements (Ridwan & Romadhon, 2019). Therefore, a thorough analysis is needed to determine the right choice to minimize costs and implementation time.

The application of the 2017 Manual of Pavement Design (MDPJ) method and the Pd T-14-2003 Concrete Pavement Planning Manual is standard in road planning in Indonesia (Ministry of Public Works, 2017). This method allows a comprehensive evaluation of the required thickness and materials according to the road characteristics and average daily traffic (Hanafi et al., 2023).

In addition, research conducted on Jalan Raya Pantai Prigi - Popoh Kab. Tulungagung by Maharani (2018) also illustrates that a combination of flexible and rigid pavement (composite pavement) can be an optimal solution for complex road conditions. This research emphasizes the importance of considering technical and economic aspects in determining the type of pavement. Research on Jalan Wolter Monginsidi (Kamil et al., 2023) and Jalan Bensol in Jambi City (Firmansyah et al., 2022) also showed that the use of rigid pavement provides significant cost efficiency in the long run. Thus, the selection of pavement type is not only influenced by initial cost, but also by life cycle cost analysis (American Association of State Highway and Transportation Officials, 1993; Austroad, 1987).

In addition to the previously mentioned studies, other studies have also made important contributions in supporting pavement analysis. The study by Putri Zayu et al. (2022) in Sawah Lunto City compared flexible and rigid pavement construction, showing that rigid pavement has higher resistance to deformation and damage due to heavy loads. This reinforces the findings of previous studies which indicate that rigid pavements are more suitable for areas with high traffic and heavy vehicle loads. In a study conducted by Kurniawan and Djunaidi (2020) on road quality improvement in Lingga Regency, it was concluded that although flexible pavements have lower initial costs, in the long run high maintenance costs can lead to higher total project costs. This finding is relevant to the condition of the Bendung - Bantengan road section which has the potential for large vehicle loads every day.

Research by Mahardika et al. (2020) in Flores revealed that paving block pavement can also be a more economical alternative for roads with light to medium traffic. However, for road conditions such as Bendung - Bantengan, paving block pavement is not ideal because it does not have the durability equivalent to rigid or flexible pavement. Another research conducted by Saefulloh (2022) on the analysis of flexible pavement thickness in Gunung Kidul Regency shows that the selection of the right thickness greatly affects the service life of the road. Using the 2017 Manual of Pavement Design (MDPJ) method, the analysis results provide recommendations for optimal thickness to reduce maintenance frequency and increase road durability.

The study by Ridwan and Romadhon (2019) in Kediri District discussed the importance of rigid pavement in reducing road damage due to waterlogging. In the context of Mojokerto district, the risk of flooding and waterlogging in some locations makes rigid pavement a more rational choice. Other technical aspects were examined in a study by Sutapa et al. (2022) in Buleleng Regency, Bali. The research indicated that a combination of flexible and rigid pavements can improve cost efficiency and extend the life of the road. This approach can be applied to the Bendung - Bantengan road section as an adaptive solution to traffic load variations.

A study conducted by Assa et al. (2022) in North Sulawesi highlighted that the use of flexible pavements with local materials can significantly reduce construction costs. This approach is relevant for Mojokerto district which has abundant local material resources. Research by the Department of Settlements and Regional Infrastructure (2002) on flexible pavement thickness planning and the Department of Settlements and Regional Infrastructure (2003) on cement concrete pavements provide technical guidelines for reference in designing pavement thickness. These guidelines are particularly relevant in the analysis of the project in Mojokerto to ensure construction in accordance with national standards.

In addition, the analysis by AASHTO (1993) and Austroad (1987) provides an international perspective on pavement planning, which can be used as an additional reference to improve the quality of planning in Indonesia. Based on these studies, this research aims to analyze and compare the cost and implementation time between concrete and asphalt pavements on the Bendung - Bantengan road section in Mojokerto Regency. It is hoped that the results of this study can serve as a reference in planning and developing road infrastructure in the area

The problems that arise in this research include the estimation of the cost budget and implementation time for the construction of concrete pavement and asphalt pavement, as well as the comparison between the two in the context of durability and efficiency. This analysis is expected to provide the right solution in choosing the most suitable pavement method to improve the quality and durability of roads in Mojokerto district.

Literature Review

Flexural Pavement

Flexural pavement is a type of pavement that uses asphalt material as the main component in the road surface layer. This structure is designed to adapt to soil deformation and provide flexibility in withstanding vehicle loads. Research by Asidin (2021) shows that flexible pavement is faster in the construction process than rigid pavement, making it suitable for use in areas with moderate traffic. In addition, the flexibility of flexible pavements helps reduce the risk of cracking and damage due to extreme temperature changes.

The main advantage of flexible pavements is the ease of repair and maintenance, which allows localized damage to be addressed quickly. The study by Assa et al. (2022) states that the maintenance cost of flexible pavements in the long term tends to be higher than rigid pavements. This is due to the nature of asphalt materials, which tend to deteriorate over time and require periodic resurfacing. However, the initial cost of constructing flexible pavement is relatively low, making it an economical choice for road projects with limited budgets.

In a study conducted by Mahardika et al. (2021), it was found that flexible pavements perform well in regions with moderate climatic conditions and light traffic. The layered structure used in flexible pavements allows for even load distribution to the subgrade, thereby reducing the potential for structural damage. The addition of adequate foundation and sub-base layers also increases the road's resistance to repeated loads. Thus, flexible pavements are an effective solution for improving the connectivity of rural and urban areas.

Kurniawan and Djunaidi (2020) stated that the use of local materials in flexible pavement construction can reduce logistics costs and speed up the construction process. The utilization of local aggregates and domestically produced asphalt helps support the local materials industry and create jobs. The research also highlighted the importance of monitoring the quality of materials during the construction process to ensure the long-term durability of the road. Therefore, the implementation of flexible pavement projects requires close cooperation between local governments and contractors.

Ridwan and Romadhon (2019) emphasized that regular maintenance on flexible pavements plays a crucial role in maintaining road quality. Works such as crack filling, resurfacing, and drainage improvements are an integral part of a regular maintenance program. Lack of maintenance can lead to further deterioration, shorten the service life of the road, and increase rehabilitation costs. Therefore, budgeting for adequate maintenance should be part of a long-term road development plan.

Rigid Pavement

Rigid pavement uses concrete as the main material in the road surface layer, providing higher resistance to heavy traffic loads. These structures are designed to have a large load-bearing capacity and a long service life, making them suitable for arterial roads and high-traffic roads (Ikons.id, 2020). Studies by Aditiya and Siswoyo (2020) show that rigid pavements are more economical in the long run despite having higher initial costs. This is because rigid pavements require less maintenance than flexible pavements.

In a study by Firmansyah et al. (2022), it was found that the resistance of rigid pavements to waterlogging and temperature changes is better than flexible pavements. The solid concrete structure reduces the risk of deformation and cracks due to weather changes. In addition, rigid pavements have the ability to withstand heavy vehicle loads without undergoing significant deformation, thus extending the life of the road. This research confirms that the use of rigid pavements is particularly suitable for areas with high rainfall and intensive industrial activity.

The study by Kamil et al. (2023) highlights that although the process of constructing rigid pavements is more complex and time-consuming, the results provide long-term benefits. The use of reinforced concrete and proper expansion joint techniques improve the road's resistance to lateral and vertical stresses. The study also identified that the optimal concrete layer thickness is critical in ensuring maximum road performance. Therefore, careful planning is required to avoid construction errors that can increase project costs.

Another study by Ahmad Irwan Hanafi et al. (2023) emphasized the importance of topography and traffic analysis in rigid pavement planning. The study found that environmental factors such as soil type and rainfall affect the design of concrete pavement thickness. In this context, CBR (California Bearing Ratio) analysis was used to determine the optimal thickness capable of supporting traffic loads. By applying this method, the rigid pavement can provide maximum performance and extend the service life of the road.

In a study by Sutapa et al. (2022), the use of rigid pavement in road improvement projects showed significant improvements in road durability and quality. The study highlights that although the initial cost of rigid pavement is higher, the efficiency in terms of maintenance and longevity provide great added value to local governments. Thus, the higher initial investment in rigid pavement is often justified by the long-term benefits gained.

Comparison of Flexural and Pavement

The comparison between flexible and rigid pavements is a major subject in many road infrastructure studies. Lelepadang et al. (2020) found that although flexible pavements have lower initial costs, rigid pavements are superior in terms of durability and resilience. This research confirms that rigid pavements are more suitable for road projects with heavy traffic and extreme weather conditions. Meanwhile, flexible pavements remain the top choice for projects with limited budgets and light traffic.

Research by Maharani (2018) shows that composite pavements that combine asphalt and concrete can be an effective solution for varying road conditions. By combining the advantages of flexural pavement flexibility and rigid pavement durability, roads can have better resistance to loads and climate change. This study highlights that composite pavements provide a balance between cost and performance. The study by Saefulloh (2022) highlights that in road projects in areas with extreme topographic conditions, a combination of flexible and rigid pavements is often used to overcome various structural challenges. This research shows that the selection of pavement type should consider traffic analysis, rainfall, and soil characteristics. Therefore, in-depth case studies are required to ensure project effectiveness.

In a study by Austroad (1987), it was concluded that the choice between flexible and rigid pavements should be based on a life cycle cost analysis. This aims to ensure that the decision made provides maximum benefits in the long run. With this method, policy makers can determine the most economical and durable pavement option. Research by AASHTO (1993) confirms that environmental factors and traffic loads play a key role in determining the most suitable pavement type. A thorough analysis of these factors allows for more effective and efficient planning of road infrastructure, ultimately improving the quality and durability of roads in the future.

The urgency of this research is driven by the increasing demand for efficient road infrastructure in regions experiencing rapid growth and heavy traffic. Mojokerto, with its diverse geography and growing transportation needs, faces significant challenges in determining the most cost-effective and durable pavement solution. Selecting the right pavement type—between concrete and asphalt—requires careful consideration of not only initial costs but also long-term durability, maintenance, and construction time. The findings of this study are crucial for guiding future road development projects, ensuring that investments in infrastructure contribute to long-term economic growth and improved connectivity.

Although there is an existing body of research comparing the benefits of concrete and asphalt pavements, most studies have been conducted in regions with different geographical and traffic conditions, leaving a gap in the context of Mojokerto. Few studies have focused on the specific characteristics of this area, such as its varying topography and the high traffic volume on roads like Bendung-Bantengan. Additionally, previous research often overlooks the combined impact of environmental factors and material availability on pavement performance. This study seeks to fill this gap by providing a localized comparison and considering the broader context of Mojokerto's infrastructure needs.

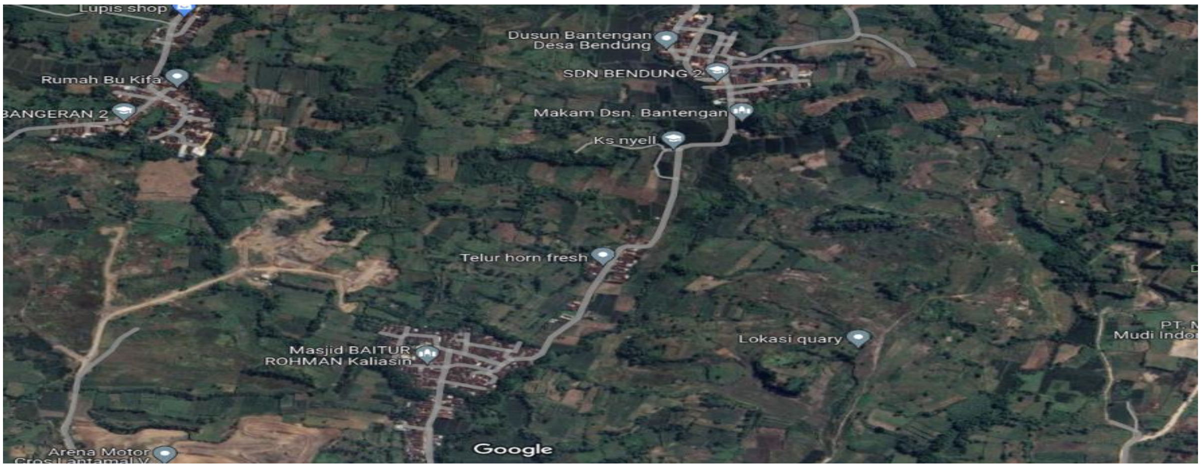
The novelty of this research lies in its localized approach to comparing concrete and asphalt pavements in Mojokerto, a region with unique topographical and traffic characteristics. While many studies have examined pavement types in general, this research adds value by integrating factors such as soil conditions, local material availability, and traffic patterns specific to the Bendung-Bantengan road section. The study also introduces a detailed cost-time analysis, considering not only initial construction costs but also long-term durability and maintenance requirements, providing a comprehensive evaluation that is particularly relevant for infrastructure planning in regions with similar challenges.

The primary objective of this study is to analyze and compare the costs, time efficiency, and long-term sustainability of concrete and asphalt pavements for the Bendung-Bantengan road section in Mojokerto. By assessing both the short-term and long-term benefits of each pavement type, the research aims to provide actionable recommendations for policymakers, urban planners, and construction professionals. The findings will help improve decision-making processes in the region, ensuring that infrastructure investments are aligned with the needs of the community while optimizing resource allocation. Ultimately, this research contributes to more efficient and sustainable infrastructure planning, with potential applications in other similar regions facing comparable challenges.

Research Methods

Location and Time of

This study was conducted on the Bendung - Bantengan road section, Mojokerto Regency, which is one of the main connecting routes between sub-districts in the region. This location was chosen due to the high intensity of daily traffic and the need to improve the quality of road infrastructure. The research was conducted over a period of six months, starting from the field survey stage to data analysis and preparation of the final report. The process involved collaboration between the research team, local government, and local contractors to ensure the validity of the data obtained.



Location
x : -7.385965°
y :
112.446070°

Map of the Study Location of the Bendung - Bantengan Road Section**.**

Data collection was conducted through field surveys that included measurements of existing road conditions, topographic analysis, and subgrade CBR (California Bearing Ratio) testing. Each road segment was analyzed in detail to get an accurate picture of the pavement needs. The survey also involved interviews with relevant parties, including road users and local authorities, to identify problems that often occur on these road segments. The survey results became the main basis for determining the most suitable pavement method to be applied.

Figure 2. Study Location of the Bendung - Bantengan Road Section**.**

The research implementation time was divided into several stages, starting with primary and secondary data collection, continuing with technical analysis, and ending with making technical recommendations. Each stage has a strict schedule to ensure the entire process goes according to plan. With this approach, it is expected that the research results can provide comprehensive and applicable solutions for the local government in improving road infrastructure in Mojokerto district.

Collection Methods

Data in this study was collected through two main methods, namely primary and secondary data collection. Primary data was obtained directly from field surveys, material testing, and road geometry measurements conducted using modern equipment. This process included measuring the thickness of the existing pavement layers, drainage conditions, and analyzing traffic density along the Bendung - Bantengan road section. Secondary data was obtained from official local government documents and previous publications relevant to road conditions in the area.

A traffic survey was conducted to measure daily vehicle volumes and the distribution of vehicle types traveling on the road. The results of this survey were then analyzed to determine the level of damage and the need for road rehabilitation. In addition, CBR testing was conducted to determine the bearing capacity of the subgrade, which is an important factor in determining the type and thickness of pavement required. All data collected was analyzed using specialized software to ensure the accuracy of calculations and planning.

The data collection process also involved visual observation of the road condition, noting cracks, potholes and deformations. Photo and video documentation was used to support this visual analysis. This method provided a comprehensive picture of the road condition and the factors affecting road deterioration. The combination of primary and secondary data ensured that the research results were accurate and reliable for infrastructure planning purposes.

Analysis and Design

Pavement analysis and design were conducted using the 2017 Manual of Pavement Design (MDPJ) method for flexible pavements and Pd T-14-2003 for rigid pavements. These methods were chosen because they have been recognized as national standards in road planning in Indonesia. The analysis process starts with calculating the average daily traffic load (LHR) and traffic growth factor to determine the optimal pavement layer thickness. Safety factors and life expectancy are also considered in this calculation.

Calculation of pavement thickness is done by considering subgrade CBR data, environmental conditions, and available material types. The analysis utilizes software such as Civil 3D and pavement design applications to ensure calculation precision. Each design alternative is tested to get the best result that is not only cost efficient but also has high durability. A comparison between flexible and rigid pavements is made to determine the most economical method that suits the road section conditions.

In addition to thickness analysis, the study also included cost and implementation time analysis. The cost budget plan (RAB) was prepared based on the unit price of work from the relevant agencies, while the implementation schedule was prepared using a Gantt diagram. With this approach, a comprehensive overview of the budget and time required for each type of pavement was obtained. The results of this analysis are expected to serve as a reference in decision-making regarding pavements in Mojokerto district.

Results and Discussions

Results

Budget Analysis

The results of the analysis show that the cost budget for the construction of concrete pavement on the Bendung - Bantengan road section reaches Rp 2,491,113,679. This calculation includes all work components, from land preparation to finishing and initial maintenance. The thickness of the planned concrete layer is 25 cm, in accordance with the Pd T-14-2003 standard. For the asphalt pavement, the required budget is IDR 3,360,913,041. The significant difference in cost is due to the need for layered materials, including 4 cm AC-WC, 6 cm AC-BC, and class A aggregate foundation. The implementation time for concrete pavement is estimated at 108 working days. The concrete curing process required additional time to ensure maximum strength could be achieved. This affected the overall duration of the project although work could proceed more quickly in the preparation stage.

In contrast, the implementation time for asphalt pavement is estimated at 120 days. Asphalt pavement requires additional time at the coating and overlay stages to ensure the quality of the road surface meets the standards. It also takes into account the weather as a factor that can slow down the field work. Overall, the analysis shows that while concrete pavement has a lower initial cost, asphalt pavement takes longer to complete. This clearly illustrates that the selection of pavement type should consider both budgetary factors and project duration.

Cost and Efficiency Comparison Results

A comparison between concrete and asphalt pavements was conducted to identify the most cost- and time-efficient option. Concrete pavements showed higher efficiency in the long run due to their better durability and lower maintenance costs. From the analysis conducted, concrete pavements have better resistance to heavy loads and extreme weather conditions. This factor is the main reason why the maintenance budget of concrete pavement is lower than asphalt pavement.

However, in terms of time, asphalt pavement has the advantage of speed of implementation. This process allows the road to be used immediately after the coating is completed, although it requires regular maintenance to maintain the surface quality. A combination of concrete and asphalt pavement was also considered as an alternative to maximize their respective advantages. By using concrete on the main lanes and asphalt on the secondary lanes, the cost and implementation time can be optimized. This comparison shows that concrete pavement is more suitable for projects with heavy traffic and extreme conditions, while asphalt pavement is more suitable for roads with moderate traffic and quick project completion needs.

Pavement Planning

Rigid pavement planning on the Bendung - Bantengan road section refers to the Pd T-14-2003 method which is used as a national standard. In this planning, the thickness of the concrete pavement is calculated based on the subgrade CBR test results and the average daily traffic volume (LHR). A thickness of 25 cm was chosen to ensure adequate strength to withstand the weight of heavy vehicles traveling on the road.

The planning process starts with topographic analysis and field testing which involves taking soil samples at various points along the road section. This data was then used in the calculation of pavement thickness using pavement design software. The results showed that the combination of the concrete layer with the class A aggregate foundation provided optimal resistance to deformation and cracking. Taking all these factors into account, the total construction cost of a concrete road is lower than that of an asphalt road. This advantage is a major factor in choosing rigid pavement as a long-term solution for road projects in Mojokerto district.

Discussion

The comparison between concrete and asphalt pavements in the Bendung-Bantengan road section reveals distinct differences in terms of cost, construction time, and long-term efficiency. Concrete pavement, despite its higher initial cost, demonstrates superior durability and cost-effectiveness over its service life. With a total construction cost of IDR 2.49 billion and a service life requiring minimal maintenance, concrete pavement is a practical solution for regions experiencing high traffic loads and stable subgrade conditions. The results align with previous studies that highlight the long-term benefits of concrete pavements in reducing maintenance frequency and costs. In contrast, asphalt pavement, costing IDR 3.36 billion, offers advantages in terms of initial construction time and flexibility. Asphalt pavement is quicker to implement and better suited for projects with tight deadlines or moderate traffic conditions. However, it requires more frequent maintenance, which increases long-term operational costs. This aligns with findings from similar studies that suggest asphalt pavement is ideal for short-term projects or areas with lighter traffic.

The study also highlights the importance of construction time. Concrete pavement requires 108 days due to the curing process but ensures better long-term performance. Asphalt pavement, completed in 120 days, allows roads to be used more quickly but involves regular maintenance every 5–7 years, impacting its cost-effectiveness. The findings emphasize the need for life-cycle cost analysis (LCCA) in selecting pavement types. In high-traffic areas like Bendung-Bantengan, concrete pavement is a more efficient and sustainable option. For low to moderate traffic conditions, asphalt pavement may remain a viable alternative. This study reinforces the critical role of traffic intensity, environmental conditions, and project goals in determining the most suitable pavement type for regional infrastructure development.

Conclusion

Based on the results of the analysis of the cost budget and implementation time for the construction of concrete pavement and asphalt pavement on the Bendung - Bantengan road section in Mojokerto Regency, several important findings were found. The cost budget for the construction of concrete pavement is Rp 2,491,113,679 with an implementation time of 108 working days. Meanwhile, the cost budget for the construction of asphalt pavement reached Rp 3,360,913,041 with an implementation time of 120 days. In terms of cost, concrete pavement is more economical than asphalt pavement. However, asphalt pavement takes longer to complete due to the layered coating process and longer curing time.

The comparison shows that concrete pavements have advantages in terms of durability and lower maintenance costs, making them a more efficient choice in the long run. In contrast, although asphalt pavement has a higher initial cost and lower durability, the implementation process is faster. Therefore, asphalt pavements are more suitable for projects with shorter time requirements and moderate traffic, while concrete pavements are more ideal for roads with heavy traffic and large vehicle loads.

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