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Comparison of Concrete Pavement and Asphalt Pavement on the Bendung-Bantengan Road Section in Mojokerto District

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ABSTRACT
Road infrastructure development is a vital aspect in supporting the economic and social growth of a region. Choosing the right type of pavement has a significant impact on cost efficiency, construction time, and road durability. This research aims to compare the specifications, costs, and implementation time of concrete and asphalt pavements on the Bendung-Bantengan road section in Mojokerto Regency. The method used is a quantitative descriptive approach with primary data collection through field surveys, CBR tests, and LHR measurements, as well as secondary data from project documents and technical literature. The results showed that concrete pavement has higher load resistance and service life with an initial cost of IDR 2,491,113,679 and an implementation time of 108 days, while asphalt pavement is more flexible with a faster implementation time (125 days) but has a higher cost (IDR 3,360,913,041) and requires more frequent maintenance. The implications of this research emphasize the importance of a life cycle cost analysis (LCCA) approach in the decision-making process of selecting the type of pavement, to create sustainable, efficient, and economical road construction.

Keywords: Concrete Pavement, Asphalt Pavement, Cost, Time, Road Infrastructure.

INTRODUCTION

Road infrastructure development is an integral part of supporting economic and social development in a region. Good infrastructure improves connectivity and facilitates the distribution of goods and services, which in turn drives economic growth. According to (McKinsey., 2020), road infrastructure plays a crucial role in improving a country's productivity and competitiveness. Therefore, choosing the right pavement type is an important aspect of road planning.

Road pavement is divided into two main types, namely flexible pavement and rigid pavement. (D. P. Umum & Rakyat, 2017) states that flexible pavement uses asphalt as the main material, while rigid pavement uses cement concrete. Each type of pavement has its own characteristics and advantages. Flexural pavements are known to have high flexibility and are

suitable for varying soil conditions, while rigid pavements have better resistance to heavy loads and a longer service life (Department of Housing and Regional Infrastructure, 2003).

In practice, flexible pavements are more widely used in Indonesia due to their lower initial cost and faster implementation process. However, according to (Sutapa et al., 2022), rigid pavements tend to be more economical in the long run as they require less maintenance. A research conducted by (Sukarno, 2022) showed that the use of rigid pavement can save up to 33% of the cost of flexible pavement in a road project in Ngawi Regency.

A similar case was also found in (Kamil et al., 2023) research on Wolter Monginsidi Road, where rigid pavement provides better resistance to heavy traffic loads. In addition, according to (Dewi, 2023), rigid pavement has higher durability, making it suitable for use on road sections with large vehicle volumes and high intensity. This is in line with (Hardiyatmo, 2015) research which shows that rigid pavements are more resistant to deformation due to repeated loads.

Research by (Aditiya & Siswoyo, 2020) on the Babat - Batas Jombang road section in Lamongan Regency showed that rigid pavement has a longer service life, so although the initial cost is higher, the total cost over the service life is lower. The results of this research are reinforced by the analysis conducted by (Firmansyah et al., 2022) on Jalan Bensol in Jambi City, which shows that rigid pavement has a higher level of cost efficiency in the long run. (Darmawan & Wibowo, 2020) in their research on the Middle Ring Road of Makassar City also confirmed that rigid pavement is more beneficial for roads with heavy traffic loads. This research showed that the construction cost of rigid pavement is lower than that of flexible pavement under heavy traffic conditions. (Mahardika, 2020) found similar results in a project on the Flores North Coast Road, where rigid pavement provided cost savings and increased road service life.

Another research by (Hanafi et al., 2023) in Bunda Asri Housing, Jombang Regency, showed that rigid pavements are more resistant to cracking and deformation, which makes them more effective in the long run. According to (Asidin & Nur, 2021), the use of flexible pavements requires more intensive maintenance, especially in areas with high rainfall and unstable soils. The American Association of State Highway and Transportation Officials (Design-Build, 2008) developed pavement design guidelines that indicate that rigid pavements have a higher load bearing capacity than flexible pavements. These guidelines are widely used as a reference in road planning in many countries, including Indonesia.

Pavement thickness greatly affects the durability and service life of roads (Nasution et al., 2019). This research showed that rigid pavements with adequate thickness can last longer and require less maintenance than flexible pavements with the same thickness. This is in line with the findings of (Assa et al., 2022) who stated that pavement thickness is a key factor in determining a road's resilience to heavy traffic loads. The Department of Housing and Regional Infrastructure (2002) in Pd T-01-2002-B states that flexible pavements require additional layers to increase the bearing capacity of the soil, while rigid pavements have a simpler but stronger structure. This guideline has become one of the main references in pavement planning in Indonesia.

The importance of considering traffic conditions and topography in the selection of pavement type was highlighted (Kurniawan & Djunaidi, 2020). They found that rigid pavements are more suitable for areas with high rainfall and heavy traffic, while flexible pavements are more suitable for roads with light traffic. In the Sungai Pinang-Mempanak Beach Road improvement project of Lingga Regency, (Kurniawan & Djunaidi, 2020) found that rigid pavement gave more satisfactory results in terms of durability and maintenance costs. This research shows that the use of rigid pavement can improve cost efficiency and extend the service life of the road.

Flexible pavements are easier to repair and faster to construct (Procurement.web.id, 2020). However, in the long run, rigid pavements are more economical and have better durability. This is in line with the findings of (Rumahstruktur.co.id, 2020) which shows that rigid pavements are more resistant to extreme weather conditions. Based on this background, this research aims to analyze and compare the pavement specifications required for the construction of concrete and asphalt pavements on the Bendung - Bantengan road section, Mojokerto Regency. The main focus is to determine the most suitable pavement type from the aspects of cost, time, and durability. Thus, road infrastructure development can run more efficiently and sustainably.

RESEARCH METHOD

Research Design

This research used a quantitative descriptive approach to compare concrete pavement and asphalt pavement on the Bendung - Bantengan road section, Mojokerto Regency. The descriptive method was chosen because it was able to provide a comprehensive overview of the technical specifications, costs, and implementation time of both types of pavements. Quantitative data was obtained from field measurements and analysis of related documents. Data analysis was conducted to identify factors influencing the selection of pavement types.

This approach aims to produce accurate and reliable information as a basis for decision-making in road planning. The main focus of this research is to compare the advantages and disadvantages of each pavement type in terms of technical specifications, durability, and cost and time efficiency. The results of the analysis are expected to contribute to the design of more durable and economical roads.

Location and Time of Research

The research was conducted on the Bendung - Bantengan road section, Mojokerto Regency, which is one of the important routes with high traffic. This location was chosen because it has diverse geographical and traffic characteristics, allowing for a comprehensive comparative analysis. The research lasted for six months, starting from the data collection stage to analyzing and reporting the results.

Figure 1. Research location of the Bendung - Bantengan road section

Figure 2. Map of the Research Location of the Bendung - Bantengan Road Section.

Location

x : -7.385965°

y : 112.446070°

The long research period allowed researchers to make in-depth observations regarding the existing condition of the road and the influence of the environment on the type of pavement used. In addition, the systematic scheduling of the research helped ensure that each stage went according to plan and produced valid data.

Data Collection

The data used in this research include primary and secondary data. Primary data was obtained through field surveys, CBR (California Bearing Ratio) tests, and Average Daily Traffic (LHR) measurements. The survey was conducted to obtain information on the existing condition of the road, while the CBR test was conducted to determine the bearing capacity of the soil. Secondary data was obtained from previous project documents, scientific publications, and technical references from the Ministry of Public Works and related institutions (K. P. Umum & Rakyat, 2013). This data was used to complement the survey results and provide a broader picture of the technical specifications and implementation methods of the pavement. The combination of primary and secondary data allowed for a more comprehensive and accurate analysis.

Data Analysis

Data analysis was conducted using the comparative method, in which concrete pavement and asphalt pavement specifications were compared based on technical aspects, costs, and implementation time. Calculations were carried out in accordance with the 2017 Pavement Design Manual (MDPJ) for asphalt pavement and Pd T-14-2003 for concrete pavement. Each parameter was analyzed in detail to obtain objective and accountable results. This analysis includes the calculation of layer thickness, material cost, and work duration based on the survey results and data collected. The results of the analysis are then presented in tables and graphs for easy interpretation and comparison. Thus, the analysis process produces relevant information to support the research objectives.

Validation and Testing

Data validation was conducted through cross-checks with pavement experts and construction practitioners. Discussions and consultations with relevant parties aim to ensure that the data and methods used are in accordance with applicable standards. Pavement trials were conducted on a small scale at specific locations to measure initial performance and ensure that the analysis results were in line with field conditions. This validation process is important to ensure the accuracy of the research results and reduce potential errors in data interpretation. The trials also provide an insight into the effectiveness and efficiency of each pavement type under real-world conditions. With rigorous validation, the research results can be used as a reference in future road infrastructure planning and development.

RESULT AND DISCUSSION

Concrete Pavement Specifications

Concrete pavement has different characteristics from asphalt pavement. Based on the analysis conducted on the Bendung - Bantengan road section, the concrete pavement specification is designed with a thickness of 25 cm. This design refers to the Pd T-14-2003 guideline which has been used as a national standard for rigid pavements. This thickness is considered adequate to withstand heavy traffic loads and maintain long-term durability of the road.

The material used in concrete pavements consists of a mixture of K-350 strength concrete with coarse and fine aggregates. This composition aims to increase structural strength as well as resistance to temperature changes and dynamic loads. In addition, steel reinforcement is also used at several points to strengthen the pavement structure. The application of this reinforcement helps to reduce the risk of cracks that can occur due to excessive loads.

Analysis of the load distribution shows that concrete pavement has better resistance to deformation than asphalt pavement. The CBR (California Bearing Ratio) test results showed a figure of 85%, which confirms that the subgrade has a high bearing capacity. Thus, concrete pavement was selected as a suitable solution for roads with high traffic intensity.

Asphalt Pavement Specifications

The asphalt pavement was designed using the 2017 Manual of Pavement Design (MDPJ) method. The asphalt layer thickness used consists of a 4 cm thick AC-WC layer, a 6 cm thick AC-BC, and a 15 cm thick class A aggregate foundation layer. This combination was chosen to ensure optimal durability and even load distribution along the road section.

This flexible pavement has high flexibility, allowing it to adjust to subgrade movements. This advantage makes asphalt pavements more resistant to small cracks caused by temperature changes and vehicle loads. However, the thickness chosen should be adjusted according to the CBR test results to ensure the stability of the foundation layer. This test indicated that the subgrade had a CBR value of 65%, which indicates a medium bearing capacity. The application of asphalt pavement is faster in the construction process compared to concrete pavement. This provides advantages in speeding up project completion and reducing traffic disruption. With lower initial costs, asphalt pavement is an economical choice for medium to high traffic roads.

Cost Comparison of Concrete and Asphalt Pavement

The cost analysis shows that concrete pavement has a higher initial cost than asphalt pavement. Based on the RAB (Budget Plan) calculation, the cost for 670 meters of concrete pavement is Rp 2,491,113,679. Meanwhile, asphalt pavement with the same length has a cost of Rp 3,360,913,041. Despite the higher initial cost, concrete pavement has the advantage of a longer service life.

This comparison shows that although asphalt pavement is cheaper in the initial implementation, the high maintenance cost in the long run makes the total overall cost greater. Therefore, in the long run, concrete pavements are more economical despite requiring a larger initial investment. The higher durability of concrete pavements means that roads require less frequent repairs compared to asphalt pavements. Asphalt pavements, on the other hand, require regular maintenance every 5-7 years to maintain the quality of the road surface. This is one of the main factors in determining the choice of pavement type.

Implementation Time

A comparison of the implementation time shows that the construction of concrete pavement takes about 108 days, while asphalt pavement takes 125 days. This difference is due to the curing process of concrete pavement which takes longer to reach maximum strength. In contrast, asphalt pavement can be used immediately after compaction and cooling.

Although it takes longer, the higher durability makes concrete pavement more profitable in the long run. The process involves around 20 workers with a clear division of tasks, so productivity is maintained throughout the project. Asphalt pavement projects are completed faster as they do not require curing time. This allows the road to be reopened in a shorter time after the project is completed. However, the higher frequency of repairs poses a challenge in maintaining the quality of the asphalt pavement.

Discussion

The comparison between concrete and asphalt pavements on the Bendung-Bantengan road section highlights significant differences in terms of specifications, costs, implementation time, and overall suitability. Concrete pavement demonstrates superior load resistance and long-term durability, making it ideal for high-traffic areas with heavy vehicle loads. This advantage is further supported by its higher resistance to deformation and cracking, ensuring a longer service life with minimal maintenance.

On the other hand, asphalt pavement offers greater flexibility and faster implementation, making it a suitable choice for projects requiring quick completion or operating under budget constraints. From a cost perspective, concrete pavement incurs a higher initial investment. However, the long-term savings due to reduced maintenance and repair needs make it a more economical option over its lifecycle. Conversely, while asphalt pavement is less expensive at the outset, frequent maintenance cycles, typically required every 5-7 years, increase its cumulative costs over time. This finding underscores the importance of adopting a life cycle cost analysis (LCCA) approach when selecting pavement types, as initial cost alone may not accurately reflect the total expenditure (Febriana, 2024).

The implementation timeline reveals another key difference. Concrete pavement requires longer construction periods due to the curing process needed to achieve maximum strength. This characteristic makes it less suitable for projects with tight deadlines. However, its extended durability offsets the longer construction time in terms of reduced disruptions for future repairs. Asphalt pavement, in contrast, allows for quicker road openings due to its shorter compaction and cooling periods. This feature makes it advantageous in high-priority projects or areas requiring immediate road functionality.

In addition to technical and financial considerations, environmental factors also play a role. Concrete pavement is more resistant to extreme weather conditions and offers greater stability on high-rainfall subgrades, as evidenced by the CBR results of 85% on this project. Asphalt pavements, while adaptable to varying conditions, are more prone to degradation under heavy rainfall or intense heat, leading to surface distortions and cracking.

The findings of this research provide valuable insights for policymakers and engineers. For high-traffic, heavy-load road sections, concrete pavement emerges as the superior choice due to its longevity and cost-effectiveness. In contrast, asphalt pavement can be a viable alternative for low-traffic areas or short-term projects with limited budgets. Additionally, integrating composite pavement designs, which combine the strengths of both types, may offer an optimal solution for specific conditions (Nawir & Mansur, 2025).

Finally, this research emphasizes the necessity of tailoring pavement type selection to the unique demands of each project. Beyond cost and technical specifications, considerations such as traffic intensity, soil stability, environmental conditions, and project timelines must guide the decision-making process. With these insights, road infrastructure planning can advance toward

more sustainable, efficient, and cost-effective practices, ultimately enhancing regional connectivity and economic development.

CONCLUSION

Based on the research comparing the specifications of concrete and asphalt pavements on the Bendung-Bantengan road section in Mojokerto Regency, it can be concluded that both pavement types have distinct advantages and disadvantages. Concrete pavement, designed with a thickness of 25 cm and K-350 strength concrete, offers high load resistance and long service life, making it ideal for high-traffic areas. Asphalt pavement, with a design using 4 cm thick AC-WC, 6 cm thick AC-BC, and 15 cm thick class A aggregate foundation layers, is more flexible and easier to repair but requires more frequent maintenance. In terms of cost, concrete pavement has a higher initial cost of Rp 2,491,113,679 but proves more economical over time due to its durability and lower maintenance needs. Conversely, asphalt pavement costs Rp 3,360,913,041 initially, with higher cumulative costs due to regular maintenance every 5-7 years. This research highlights the importance of considering traffic volume, budget, and durability when selecting pavement types. In the future, this research contributes to optimizing road infrastructure decision-making by promoting a more data-driven approach to pavement selection and encouraging the use of life cycle cost analysis (LCCA) for more sustainable and cost-effective road maintenance strategies.

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