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A Comparative Study of Materials in the Design of Concrete and Asphalt Road Pavements in Terms of Cost and Time (Case Study of the Sumberwudi-Maduran Road Section, Lamongan Regency, East Java Province)

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A B S T R A C T

This research is highly urgent in bridging the knowledge gap between standard theory, field practice, and the dynamics of current industrial area development. The construction and periodic maintenance budget for asphalt road pavement with a duration of 20 years requires a cost of Rp. 17,638,200,000.00, then the construction and periodic maintenance budget for asphalt road pavement with a duration of 40 years requires a cost of Rp. 52,225,100,000.00. The construction and periodic maintenance budget for 20-year UR concrete road pavement requires a cost of Rp. 9,063,000,000.00, then the construction and periodic maintenance budget for 40-year UR concrete road pavement requires a cost of Rp. 15,031,400,000.00.

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INTRODUCTION

Road infrastructure plays a strategic role in supporting economic growth and improving regional connectivity at both national and regional levels. As the backbone of land transportation, the road network connects centers of socio-economic activity, industrial areas, residential areas, and production centers with markets and distribution facilities. Adequate road infrastructure can reduce logistics costs, accelerate the distribution of goods and services, and support the effectiveness of community economic activities. Therefore, road development and quality improvement are key indicators in strengthening regional and national competitiveness.

At the regional level, particularly in East Java Province, road connectivity is crucial for integrating economic support areas such as industrial, agricultural, and commercial sectors. Lamongan Regency, as an agricultural and developing region in East Java, requires a reliable road network to facilitate the transportation of agricultural commodities, fishery products, and the flow of people. The Sumberwudi-Maduran Road section serves as a vital access route, connecting rural areas with distribution centers at the sub-district and regency levels. The condition and quality of the road pavement along this section significantly affect local economic efficiency, the smooth distribution of goods, and public accessibility to services.

In northern Lamongan, the Lamongan Smooth Road (Jamula) initiative continues to improve road conditions. As of October 2025, the regency road stability reached 59.97% (approximately 400,138 km of the ±667 km network), highlighting the need for further improvements, particularly on strategic sections connecting production and residential areas (Radar Bangsa, 2025). Traffic growth, reflected by increasing motorized vehicle numbers, further emphasizes the rising demand for road capacity and durability (BPS Indonesia, 2024).

The Sumberwudi-Maduran section, approximately 10 km long, functions as a logistics corridor supporting industrial and fisheries sectors. The area is characterized by dense spatial functions including residential zones, local markets, and fishponds, which contribute to high traffic intensity. Heavy vehicles transporting production goods dominate the traffic, imposing high axle loads and frequent movement, which directly impact road pavement conditions. Selecting appropriate pavement types—concrete (rigid) or asphalt (flexible)—is crucial to balance structural performance, construction and maintenance costs, service life, and minimization of traffic disruption.

THEORETICAL REVIEW

Flexible and rigid pavements are the two main types of road construction widely applied in infrastructure projects. Flexible pavement consists of a surface layer of asphalt concrete mixture over base and sub-base layers, which distribute traffic loads to the subgrade. Its primary advantage is flexibility, allowing slight deformation without structural failure. However, flexible pavements generally require more frequent maintenance and greater total structure thickness compared to rigid pavements (DPUPR Grobogan, 2014).

In contrast, rigid pavement uses a concrete slab to distribute loads over a wider area of the subgrade. Concrete pavements are known for their durability and high load-bearing capacity, making them suitable for areas with heavy vehicle traffic. Comparative studies show that while asphalt allows faster construction and easier repair, concrete provides longer service life and reduced maintenance frequency, making it economically advantageous for industrial and logistics corridors over the long term.

Traffic load, subgrade characteristics, and environmental factors significantly influence pavement deterioration. Common damage in regional roads includes deformation (rutting/waviness), fatigue cracks, alligator cracks, potholes, and edge failures. Excessive loads, subgrade instability, poor drainage, and climate cycles accelerate degradation. High-frequency traffic on industrial/logistics roads, such as the Sumberwudi-Maduran section, amplifies the rate of deterioration, highlighting the importance of proper pavement structural design to extend service life and minimize maintenance costs.

Economic and strategic considerations also play a role in pavement selection. Life-cycle cost analysis, construction duration, and minimization of traffic disruption are crucial factors when deciding between flexible and rigid pavements. Studies suggest that rigorous analysis of material performance, cost-efficiency, and implementation feasibility is essential for infrastructure in regions with heavy traffic and high economic activity, like northern Lamongan. A comparative study of concrete and asphalt pavements is therefore relevant for developing optimal design recommendations that support logistics connectivity, regional economic growth, and sustainable road performance.

METHODOLOGY

The series of stages begins with the identification of problems based on field phenomena, namely the existing condition of the road pavement on the Sumberwudi – Maduran Road section, Lamongan Regency, which mostly uses asphalt pavement and shows various structural damage. This condition raises the need to conduct a comprehensive evaluation of alternative types of road pavement that are more efficient and have better durability. After the problem is clearly defined, the research objectives are set which are focused on a comparative analysis between concrete (rigid) road pavement and asphalt (flexible) road pavement in terms of cost and time with a design life of 20 years and 40 years. The research location is determined on the Sumberwudi – Maduran Road section, Lamongan Regency.

The next step is to collect primary data through on-site surveys. This primary data includes:

- Photographic documentation: Used as visual evidence of the actual condition of the road section, including damage, existing pavement type, and the surrounding environmental conditions.
- Road pit testing: Excavating samples of the existing pavement layer to obtain visual and physical data of the old structure.

The collected traffic data is analyzed to obtain the cumulative standard axle load (CESA) and the number of commercial vehicle axles (JSKN). This calculation is performed using the formulas listed in the 2024 MDPJ. This stage also involves calculating the annual traffic growth rate based on historical data and commercial vehicle distribution factors based on the number of lanes and traffic direction. The results of the traffic analysis will be used as a basis for determining the thickness of the designed pavement structure.

Both pavements use the 2024 MDPJ calculation, with the rigid pavement using the JSKN value and the flexible pavement using the CESA value. Designed service lives are 20 and 40 years, respectively. This stage will determine the material requirements and work volume, which will be calculated in the cost analysis.

Once the designs for both pavement types are complete and meet the established specifications, the next step is to calculate the Cost Budget Plan (RAB) and estimate the implementation time. Next, a comparison is made between the two pavement types to determine which is more efficient in terms of implementation time and more economical.

The final stage of the research is to draw conclusions based on the results of the comparative analysis. The conclusions should address all of the proposed research questions. This study also provides implementable recommendations for readers who will use this research as a reference for future research.

RESULTS AND DISCUSSION

Based on the analysis conducted in the study entitled "Comparative Study of Materials in Concrete and Asphalt Pavement Design in Terms of Cost and Time (Case Study of the Sumberwudi-Maduran Road Section, Lamongan Regency, East Java Province)," the following results can be summarized:

1. LHR Projection:
Calculating LHR data for 2045 and 2065.
2. Design Dimensions of the Planned Road Pavement:
a. 20-year UR asphalt:
AC – WC = 40 mm = 4 cm
AC – BC = 145 mm = 14.5 cm
LPA Class A = 100 mm = 10 cm
With an increase in the height of the existing road by 24.5 cm

b. 40-year UR asphalt:
AC – WC = 40 mm = 4 cm
AC – BC = 155 mm = 15.5 cm
AC Base = 100 mm = 10 cm
LPA Class A = 200 mm = 20 cm
With an increase in the height of the existing road by 45.5 cm

c. 20-year UR road concrete slab:
Concrete slab with Fs 4.5 MPa, 22 cm thick
□Dowel diameter = 36 mm
□Dowel length = 450 mm mm
□Dowel spacing = 300 mm
Fc′ 10 MPa thin concrete, 10 cm thick

With an increase in the height of the existing road by 32 cm

d. 40-year UR road concrete slab:
Fs 4.5 MPa concrete slab, 25 cm thick
□Dowel diameter = 36 mm
□Dowel length = 450 mm
□Dowel spacing = 300 mm
Fc′ 10 MPa thin concrete, 12.5 cm thick
With an increase in the height of the existing road by 37.5 cm

1. The budget for the construction and periodic maintenance of a 20-year asphalt pavement requires a cost of Rp 17,638,200,000.00, followed by the budget for the construction and periodic maintenance of a 40-year asphalt pavement.
2. The budget for the construction and periodic maintenance of a 20-year concrete pavement requires a cost of Rp 9,063,000,000.00, followed by the budget for the construction and periodic maintenance of a 40-year concrete pavement.

4. Implementation Time:

a. Estimated construction time for the Sumberwudi-Maduran asphalt road section with a design life of 20 years with 20 workers is 31 calendar days, and for the Sumberwudi-Maduran asphalt road section with a design life of 40 years with 20 workers, it is 37 calendar days.
The estimated construction time for the 20-year UR concrete road pavement is 180 calendar days with 20 workers, and the estimated construction time for the 40-year UR concrete road pavement is 205 calendar days with 20 workers.
In general, the specifications and quality of both pavements must be able to accept three-axle vehicles and can last according to the specified design life, but looking at asphalt pavements which require repairs every 10 years while concrete pavements require periodic maintenance every 20 years, then according to general opinion the quality and specifications of concrete pavements are better than asphalt pavements.

CONCLUSION AND RECOMMENDATION

Based on the results of pavement planning analysis using the MDPJ 2024 method in a study entitled "Comparative Study of Materials in Concrete and Asphalt Pavement Planning in Terms of Cost and Time (Case Study of the Sumberwudi-Maduran Road Section, Lamongan Regency, East Java Province)," several important findings were obtained, as follows:

1. Based on the LHR projection for the Sumberwudi-Maduran Road section until the 40th plan year (2065), there has been a very significant increase in traffic, with passenger vehicles reaching 135,449 vehicles/day, Pickup/Micro Trucks 39,569 vehicles/day, and large two-axle trucks 29,085 vehicles/day. This condition forms the basis for determining the pavement design for the 20- and 40-year design lives. For UR 20 years, asphalt pavement consists of AC-WC 4 cm, AC-BC 14.5 cm, LPA Class A

10 cm (24.5 cm elevation), while concrete pavement uses a 22 cm thick slab on top of 10 cm thin concrete (32 cm elevation). For UR 40 years, asphalt pavement is planned with AC-WC 4 cm, AC-BC 15.5 cm, AC-Base 10 cm, LPA Class A 20 cm (45.5 cm elevation), while concrete pavement uses a 25 cm thick slab on top of 12.5 cm thin concrete (37.5 cm elevation).

2. The cost calculation results show that concrete pavement is much more economical than asphalt pavement at both design ages. For a design age of 20 years, the total cost of construction and maintenance of asphalt pavement reaches Rp17,638,200,000, while concrete pavement only costs Rp9,063,000,000. At a design age of 40 years, asphalt pavement requires Rp52,225,100,000, while concrete only costs Rp15,031,400,000. This very large cost difference illustrates that concrete pavement provides significant financial benefits, especially for long-term service needs.
3. In terms of implementation time, asphalt pavement is much faster to complete. For the 20- and 40-year design lives, asphalt work with 20 workers requires 31 and 37 calendar days, respectively. Meanwhile, concrete pavement work requires 180 days for the 20-year design life, and 205 days for the 40-year design life. Nevertheless, concrete pavement remains a more sustainable choice under heavy traffic conditions due to its higher durability.

FUTHER STUDY

The author's suggestions are expected to be constructive:

1. Future research should consider not only technical aspects but also include additional factors such as driving comfort, potential emission reductions during construction, and social and economic impacts on local communities to provide a more comprehensive analysis of pavement type selection.
2. Future studies should review the actual service life of pavements in the field, allowing comparison with the theoretical design life and providing a more realistic picture of the performance of each pavement type.

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