



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

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### ABSTRACT

In order to close the knowledge gap between conventional theory, field practice, and the dynamics of contemporary industrial area growth, this research is extremely important. A budget of Rp 17,638,200,000.00 is needed for the construction and periodic maintenance of asphalt road pavement over a 20-year period, and Rp 52,225,100,000.00 is needed for asphalt road pavement over a 40-year period. A budget of Rp 9,063,000,000.00 is needed for the construction and annual maintenance of a 20-year UR concrete road pavement, while Rp 15,031,400,000.00 is needed for a 40-year UR concrete road pavement.

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## **INTRODUCTION**

At both national and regional levels, road infrastructure is crucial for promoting economic growth and enhancing regional connectivity. The road network, which serves as the foundation for land transportation, links production hubs with markets and distribution facilities, industrial regions, residential areas, and centers of socioeconomic activity. Adequate road infrastructure can increase the efficiency of local economic operations, reduce logistics costs, and accelerate the delivery of goods and services. Therefore, road development and quality improvement are key factors in strengthening regional and national competitiveness.

At the regional level, especially in East Java Province, road connectivity is essential for linking economic support areas such as industrial, agricultural, and commercial zones. Lamongan Regency, an agricultural and developing region, requires a reliable road network to facilitate the movement of people and the transportation of agricultural and fisheries products. The Sumberwudi-Maduran Road segment serves as a critical access point, connecting rural communities with distribution centers at both sub-district and regency levels. The condition and quality of the road surface on this section significantly impact local economic efficiency, smooth distribution, and public access to services.

The Lamongan Smooth Road (Jamula) initiative is an ongoing program aimed at improving road conditions, particularly in northern Lamongan. As of October 2025, regency road stability reached only 59.97% (approximately 400,138 km of the total ±667 km network), highlighting the need for improvements on strategic sections connecting production and residential areas (Radar Bangsa, 2025). Increasing traffic volumes, reflected in the growth of motorized vehicles, further underscore the demand for stronger and more durable roads (BPS Indonesia, 2024).

The Sumberwudi-Maduran section, approximately 10 km in length, functions as a logistics corridor supporting industrial and fisheries sectors. Heavy vehicles dominate traffic, transporting goods from production sites to distribution points and coastal ports. Without proper pavement design and material selection, surface and substructure damage will occur prematurely, leading to higher maintenance costs and traffic disruption. Consequently, selecting the most suitable pavement type—rigid (concrete) or flexible (asphalt)—is essential for balancing structural performance, cost, and construction time.

## **THEORETICAL REVIEW**

Flexible and rigid pavements are the two primary types of road construction commonly applied in infrastructure projects. Flexible pavement consists of an asphalt surface layer over base and sub-base courses, which distribute traffic loads to the subgrade. Its main advantage is flexibility, allowing minor settlement or rutting during service life. However, flexible pavements generally require thicker structures and more frequent maintenance compared to rigid pavements (DPUPR Grobogan, 2014).

Rigid pavement, on the other hand, uses a concrete slab to distribute loads over a wider area of the subgrade. Concrete pavements are highly durable and

suitable for areas with heavy traffic, such as industrial and logistics corridors. While asphalt pavements allow for faster construction and easier repairs, concrete pavements offer longer service life and reduced maintenance frequency, providing economic benefits over the long term.

Traffic load, subgrade conditions, and environmental factors significantly affect pavement deterioration. Common forms of damage include deformation (rutting/waviness), fatigue cracks, alligator cracks, potholes, and edge failures, often caused by excessive loads, subgrade instability, poor drainage, and climatic cycles. Heavy traffic, especially from industrial/logistics vehicles, accelerates pavement deterioration, highlighting the importance of proper structural design to extend service life and reduce maintenance costs.

Economic and strategic considerations are also crucial in pavement selection. Life-cycle cost analysis, construction time, and minimization of traffic disruption are key factors when choosing between flexible and rigid pavements. Comparative studies emphasize that a careful evaluation of material performance, cost-efficiency, and feasibility is essential in high-traffic, high-load areas like northern Lamongan. Such analyses provide a scientific basis for selecting the most effective pavement option to enhance logistics connectivity, support economic growth, and improve road infrastructure stability in the region.

## **METHODOLOGY**

The first step of the process is identifying issues based on field observations, such as the state of the road pavement on the Sumberwudi-Maduran Road segment in Lamongan Regency, which primarily employs asphalt pavement and has varied structural degradation. This situation necessitates a thorough assessment of more durable and effective alternate forms of road surface. The research objectives, which center on a comparison of the cost and time of concrete (rigid) and asphalt (flexible) road pavement with design lives of 20 and 40 years, are established after the problem has been clearly characterized. The Sumberwudi-Maduran Road segment in Lamongan Regency has been identified as the research site.

The next stage is to use on-site surveys to gather primary data. Photographic documentation, which serves as visual proof of the road section's actual condition, including damage, the type of pavement that is already in place, and the surrounding environmental conditions, is one type of primary data.

Road pit testing involves excavating samples of the current pavement layer in order to get physical and visual information about the ancient construction.

The number of commercial vehicle axles (JSKN) and the cumulative standard axle load (CESA) are determined by analyzing the gathered traffic data. The 2024 MDPJ's formulas are used to carry out this computation. In this step, the yearly traffic growth rate is also calculated using historical data and commercial vehicle distribution parameters based on traffic direction and lane count. The thickness of the planned pavement construction will be determined using the traffic analysis data.

Both pavements make use of the 2024 MDPJ computation; the flexible pavement uses the CESA value, while the stiff pavement uses the JSKN value. The intended service lives are 20 and 40 years, respectively. This phase will ascertain the job volume and material requirements, which will be computed in the cost analysis.

The next stage is to compute the Cost Budget Plan (RAB) and project the implementation time after the designs for both pavement types are finished and satisfy the specified requirements. The two pavement types are then compared to see which is more cost-effective and efficient in terms of installation time.

Drawing conclusions from the comparative analysis's findings is the last phase of the study. All of the above research questions should be included in the findings. For readers who may use this study as a reference for future research, it also offers practical recommendations.

## **RESULTS AND DISCUSSION**

The findings of the study "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)," can be summed up as follows:

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  $F_s$  4.5 MPa, 22 cm thick

□Dowel diameter = 36 mm

□Dowel length = 450 mm mm

□Dowel spacing = 300 mm

$F_c'$  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:

$F_s$  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

- a. 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.
- b. 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

- a. Several significant conclusions were drawn from the pavement planning analysis conducted using the MDPJ 2024 method in a study titled "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)," including the following:
- b. According to the LHR estimate for the Sumberwudi-Maduran Road stretch, traffic has increased significantly until the 40th plan year (2065). Passenger vehicles reached 135,449 cars per day, pickup/micro trucks 39,569 vehicles per day, and heavy two-axle trucks 29,085 vehicles per day. The pavement design for the 20- and 40-year design lives is based on this condition. For UR 20 years, concrete pavement employs a 22 cm thick slab on top of 10 cm thin concrete (32 cm elevation), whereas asphalt pavement uses AC-WC 4 cm, AC-BC 14.5 cm, and LPA Class A 10 cm (24.5 cm elevation). While concrete

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

- c. 3. At both design ages, concrete pavement is significantly more cost-effective than asphalt pavement, according to the cost calculation results. Concrete pavement only costs Rp9,063,000,000, whereas asphalt pavement costs Rp17,638,200,000 for construction and upkeep over a 20-year design age. Concrete only costs Rp15,031,400,000 at a design age of 40 years, whereas asphalt pavement costs Rp52,225,100,000. This enormous cost differential shows how concrete pavement offers substantial financial advantages, particularly for long-term maintenance requirements.
- d. Asphalt pavement takes a lot less time to implement. Asphalt work with 20 people takes 31 and 37 calendar days, respectively, for the 20- and 40-year design lifetimes. For the 20-year design life, concrete pavement work takes 180 days; for the 40-year design life, it takes 205 days. However, because concrete pavement is more durable, it is still a more environmentally friendly option when there is a lot of traffic.

## **RECOMMENDATION**

It is anticipated that the author's recommendations will be helpful in order to provide a more thorough study of pavement type selection, future research should take into account not just technical issues but also additional factors including driving comfort, potential emission savings during construction, and social and economic consequences on local populations.

## **FURTHER STUDY**

In order to provide a more accurate image of each pavement type's performance and enable comparison with the theoretical design life, future research should examine the actual service life of pavements in the field.

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