

Planning for the Reconstruction of the Sari Wangi Road to Beringin Agung, Samboja District

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Abstract: This study focuses on the reconstruction planning of Jalan Sari Wangi to Beringin Agung in Samboja District, East Kalimantan, which has become a vital access route for both local and industrial traffic. Increased vehicle volume and inadequate previous pavement have led to rapid road deterioration, highlighting the urgent need for structural improvement. The AASHTO 1993 method was employed to design a rigid pavement system capable of sustaining future traffic demands over a 21-year design life. Primary data, such as traffic volume surveys, and secondary data from government agencies, including soil characteristics and CBR values, were analyzed. The design resulted in a rigid pavement thickness of 32 cm supported by a 15 cm base layer. Reinforcement and joint designs, including dowels and tie bars, were specified to ensure structural integrity. The Degree of Saturation (DS) analysis confirmed that the proposed design will accommodate traffic until 2046, with DS values remaining below the critical threshold of 0.85. The estimated construction cost for the 336-meter road section is Rp 2.67 billion. This investment is considered economically feasible, given the expected improvement in road durability, serviceability, and contribution to regional connectivity and development. The study underscores the importance of adopting performance-based pavement design and integrating long-term planning with reliable forecasting models.

Keywords: AASHTO 1993; Rigid Pavement; Road Reconstruction



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1. Introduction

Infrastructure development, particularly road networks, plays a crucial role in supporting economic growth (Sharma et al., 2024), facilitating mobility, and increasing regional connectivity (Lestari et al., 2025; Nseobot et al., 2023). In many developing regions, inadequate road infrastructure contributes to increased transportation costs and limits access to essential services (Ng et al., 2019). Well-maintained road infrastructure can reduce vehicle operating costs by up to 30% and significantly improve access to education, healthcare, and employment (Berg et al., 2017; Straub, 2008). In this context, reconstruction planning of strategic road sections is necessary to improve traffic performance and ensure road sustainability in the face of rising vehicle volumes and environmental challenges.

Jalan Sari Wangi to Beringin Agung in Samboja District has become a vital route connecting residential, industrial, and commercial zones in East Kalimantan. Originally a low-traffic area, it now experiences high vehicular flow due to population growth and the expansion of nearby economic activities (Mohamad, 2024) such as factories, offices, and housing developments. As traffic volume increases, the existing pavement structure has shown signs of deterioration, including rutting, cracking, and surface damage, which compromise road safety and service levels (Housing, 2017; Kololikiye et al., 2024). The

growing presence of heavy vehicles, particularly trucks and construction equipment, further accelerates the rate of road damage and shortens its service life (Kici & Tigdemir, 2017; Solanki & Zaman, 2017).

In response to these challenges, a reconstruction plan involving rigid pavement design has been proposed to enhance the structural performance and longevity of the road. The AASHTO 1993 design method was chosen due to its established reliability in determining pavement thickness based on traffic load, soil condition, and service life expectations (AASHTO, 1993; Bendana & Yang, 1993; Firgiansyah et al., 2022). This study aims to analyze the current condition of the road, forecast future traffic demand, and provide a comprehensive technical plan for reconstruction that ensures optimal load-bearing capacity, reduced maintenance frequency, and cost-effective investment.

2. Materials and Methods

2.1 Data Collection

This study used a combination of primary and secondary data:

1. Primary Data: Traffic volume surveys (LHR) conducted directly in the field on Jalan Sari Wangi – Beringin Agung.
2. Secondary Data: California Bearing Ratio (CBR) test results and soil characteristics obtained from the Kutai Kartanegara Highway and Public Works Office.

2.2 Pavement Design Method

The rigid pavement thickness was calculated using the AASHTO 1993 design method. This method is based on a mechanistic-empirical approach that considers design life, traffic loads (ESAL), concrete properties, subgrade reaction, and serviceability loss.

2.3 Key Input Parameters

- | | |
|---|--------------------|
| 1. Design life (n) | = 21 years |
| 2. ESAL (W_t) | = 65,881,464.29 |
| 3. Reliability (R) | = 85% |
| 4. Standard normal deviate (Z_a) | = -1.037 |
| 5. Overall standard deviation (S_0) | = 0.30 |
| 6. Initial serviceability (P_0) | = 4.5 |
| 7. Terminal serviceability (P_t) | = 2.5 |
| 8. Modulus of subgrade reaction (k) | = 232 pci |
| 9. Compressive strength of concrete (fc') | = 4977 psi |
| 10. Modulus of elasticity (E_c) | = 4,021,228 psi |
| 11. Concrete modulus of rupture (S'_c) | = 530 psi |
| 12. Load transfer coefficient (J) | = 2.55 |
| 13. Drainage coefficient (Cd) | = 1.0 |
| 14. Slab thickness (D) | = to be calculated |

2.4 Design Formula

The general formula used in the AASHTO 1993 method for rigid pavement is:

$$\log_{10}(W_{18}) = Z_r \cdot S_0 + \log_{10} \left(\frac{(S'_c \cdot D^{0.75})}{(k \cdot 10^6) \cdot (1 + 1.624 \cdot \log_{10}(D))} \right) \quad (1)$$

Where:

- W₁₈** : predicted number of 18-kip ESAL applications
D : slab thickness (inches)
Z_r : standard normal deviate for reliability
S₀ : overall standard deviation
S'_c : modulus of rupture of concrete (psi)
k : modulus of subgrade reaction (pci)

The calculation is done iteratively by trial and error until the value of $W18$ approximates the target ESAL.

2.5 Reinforcement and Dowel Design

a. Tie Bar Design

Tie bar area per meter (A_s):

$$A_s = \frac{18 \times f \times h \times b}{\sigma_s} \quad (2)$$

Where:

- f : coefficient of friction (1.8)
- h : slab thickness (mm)
- b : width (m)
- σ_s : yield strength (MPa)

b. Minimum Steel Requirement (SNI 1991):

$$A_{s \min} = 0.14\% \times h \times 1000 \quad (3)$$

Where:

- h : slab thickness (mm)

c. Dowel Spacing

Using standard guideline:

- Dowel diameter : 25 mm
- Length : 450 mm
- Spacing : 300 mm

d. Tie Bar Specification

Using standard guideline:

- Diameter : 16 mm
- Length : 650 mm
- Spacing : 600 mm

3. Results

3.1 Traffic Volume and Capacity Analysis

The results of the average daily traffic (LHR) survey revealed that the current vehicle load has exceeded the service capacity of the existing pavement. Using PKJI 2014 parameters, the planned capacity (C) of the 2/2 TT road with 5-meter width was calculated as follows:

$$C = C_o \times FCIJ \times FCPA \times FCHS$$

$$C = 3100 \times 1.29 \times 1.00 \times 0.94 = 3759.06 \text{ smp/hour}$$

From this, the degree of saturation (DS) values for different time horizons were computed:

- a. 2025–2046: $DS < 0.85$ → Road still operates under acceptable capacity
- b. 2046–2066: $DS > 0.85$ → Road will be over capacity, requiring future upgrades

These values indicate that the designed road section can sustain acceptable performance levels for up to 21 years.

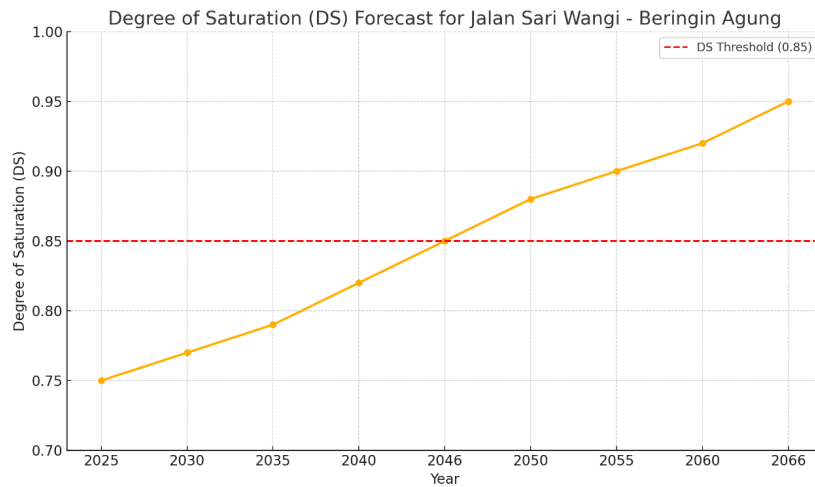


Figure 1. Illustrates the Projection of Degree of Saturation (DS) from 2025 to 2066.

The threshold value of $DS = 0.85$, shown as a red dashed line, indicates the maximum acceptable saturation for optimal road function. It is evident that by the year 2046, the DS begins to exceed this limit, thus supporting the argument for potential upgrades or traffic control policies post-2046.

3.2 CBR and Subgrade Analysis

CBR value obtained from secondary data was 3%, indicating weak subgrade support. Using the graphical method and AASHTO 1993 guidance, this translates to a subgrade reaction modulus (k) of approximately 232 pci. A weak subgrade requires a thicker rigid pavement slab to distribute load efficiently and avoid structural failures.

3.3 Pavement Thickness Design Using AASHTO 1993

Using ESAL values of 65,881,464.29, a reliability of 85%, and a final serviceability index of 2.5, the rigid pavement thickness (D) was determined iteratively using the AASHTO 1993 formula. The calculation resulted in:

$$D = 1240in = 315cm \rightarrow \text{rounded to } 32cm \quad (6)$$

Additionally, a base layer thickness of 15 cm was included to support the concrete slab.

3.4 Reinforcement and Dowel Bar Design

The following structural components were determined based on design requirements and standard specifications:

1. Longitudinal Reinforcement: $\varnothing 12$ mm @ 250 mm spacing, $A_s = 452$ mm²/m
2. Minimum Required Steel Area: 448 mm²/m (SNI 1991), so provided reinforcement meets standard
3. Dowel Bars:
 - a. Diameter: 25 mm
 - b. Length: 450 mm
 - c. Spacing: 300 mm
4. Tie Bars:
 - a. Diameter: 16 mm
 - b. Length: 650 mm
 - c. Spacing: 600 mm

These details ensure that the pavement will have sufficient joint performance and continuity while preventing slab movement.

3.5 Cost Budget Plan (RAB)

Based on the design, the estimated reconstruction cost for the road section STA 0+000 to 0+336 with 5-meter width was calculated at:

Total Cost = Rp2,674,380,000

This budget includes material, labor, reinforcement, joint elements, and subgrade preparation. The cost aligns with national estimates for rigid pavement in similar terrain and design conditions.

4. Discussion

The reconstruction planning of Jalan Sari Wangi to Beringin Agung using rigid pavement demonstrates a proactive approach to addressing increasing traffic demand and deteriorating road conditions in Samboja District. The traffic volume projection and degree of saturation (DS) analysis indicate that the designed road configuration (2/2 TT, 5 meters wide) can adequately serve traffic up to the year 2046, maintaining DS below the critical threshold of 0.85. This aligns with national infrastructure planning guidelines, which emphasize capacity adequacy and long-term serviceability in road design (Bina Marga, 2017).

The selection of the AASHTO 1993 method proved appropriate for this context, as it allows for the detailed consideration of subgrade conditions (CBR = 3%), traffic load (ESAL = 65 million), and material properties. The resulting slab thickness of 32 cm and base layer of 15 cm reflect the need for a high-capacity pavement structure in weak soil conditions. These values are consistent with findings from similar studies in Indonesia, where rigid pavements have been applied in high-load corridors with suboptimal subgrade strength (Azis, 2012; Hamid & Wildan, 2020).

Furthermore, the inclusion of dowel and tie bars based on standard design criteria ensures joint stability and minimizes potential slab movement or faulting. The cost estimation of approximately Rp 2.67 billion is a significant but justifiable investment, especially when weighed against the long-term benefits of improved connectivity, reduced maintenance, and support for economic growth. However, as the DS is projected to exceed 0.85 post-2046, supplementary planning should include strategies for traffic redistribution, road widening, or periodic rehabilitation. This aligns with sustainable infrastructure management principles, which recommend monitoring traffic patterns and adopting adaptive maintenance models (Berg et al., 2017; Straub, 2008).

5. Conclusions

This study successfully planned the reconstruction of Jalan Sari Wangi to Beringin Agung using the AASHTO 1993 method, which is suitable for high-load traffic and weak subgrade conditions. The analysis resulted in a rigid pavement thickness of 32 cm with a 15 cm base layer, designed to serve traffic demand for 21 years (until 2046) while maintaining acceptable levels of service (DS < 0.85). Reinforcement details, including dowels and tie bars, were determined to ensure structural stability and minimize joint movement.

The total estimated cost for the 336-meter road section is approximately Rp 2.67 billion. This investment is considered efficient given the long service life and reduced maintenance needs. The reconstructed road is expected to significantly improve access, reduce vehicle operating costs, and support local economic development in Samboja District.

The findings emphasize the importance of using performance-based design methods, accurate traffic projections, and proper structural detailing to ensure pavement longevity and functionality. Future upgrades may be needed beyond 2046 to accommodate increasing traffic volumes.

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