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Evaluation of the Structural Teratment of the Tonusu Pendolo Road Section, Poso Regency

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ABSTRACT

The Tonusu–Pendolo Road Section in Poso Regency, Central Sulawesi, is a vital 58.5 km transportation corridor linking Pamona Barat and Pendolo Districts, serving both economic activities and ecologically sensitive areas such as the Pamona Nature Reserve and Bancea Natural Tourism Park. However, field surveys reveal that the pavement condition ranges from light to severe damage, with visible defects such as cracks, potholes, rutting, and depressions. The research problem lies in inadequate pavement durability caused by excessive axle loads, poor drainage, and low subgrade strength, which threaten road safety and regional connectivity. This study aims to analyze the existing pavement condition and propose an optimal structural improvement strategy using the Bina Marga Flexible Pavement Design Method. Data collection involved traffic volume surveys, subgrade CBR testing, and visual pavement inspections. Results indicate subgrade CBR values of 5–8%, necessitating a reinforced pavement layer. The proposed design includes a 4 cm Asphalt Concrete Wearing Course (AC-WC), 6 cm Asphalt Concrete Binder Course (AC-BC), 20 cm Aggregate Class A base, and 20 cm Aggregate Class B subbase. These findings suggest that the integration of structural reinforcement, axle load regulation, drainage improvements, and scheduled maintenance can significantly enhance road performance, extend service life, and support sustainable regional development.

Keywords: Tonusu–Pendolo Road, flexible pavement design, CBR, structural improvement, Bina Marga method

INTRODUCTION

Roads are one of the primary land transportation infrastructures, designed and constructed according to the needs and conditions of a given region. They are equipped with structures and supporting facilities to serve road users (Adugbila et al., 2023; Aryan et al., 2023; de Abreu et al., 2022; Khanani et al., 2021; Wang et al., 2020). The primary function of roads is to connect different areas, thus playing a vital role in promoting equitable economic conditions within society. When road conditions are adequate and in good shape, the distribution of goods and services within the region can take place more efficiently. Therefore, road construction must ensure safety and comfort for both motorists and pedestrians using the facility (Rivera et al., 2020; Segui et al., 2023; Son et al., 2024; Trunzo et al., 2019; Wubet et al., 2023).

The rapid economic growth in Indonesia, coupled with equitable welfare and a continuously increasing population, has contributed to the surge in the number of vehicles, particularly in the land transportation sector. Furthermore, the availability of affordable vehicles has accelerated the rise in vehicle ownership (Brueckner & Lederman, 2018; Halilintar, 2018; Laila Hasyim Tambun et al., 2023; Nugraha et al., 2020; Safrita et

al., 2021). At present, owning a private vehicle is no longer considered a luxury but a necessity to support daily activities. However, this increase in vehicle numbers has also led to a decline in road service quality, insufficient supporting facilities, and a reduction in the functional capacity of the roads themselves. To address these issues, it is necessary to expand the road network, repair damaged facilities, and enhance road functions to improve user comfort—such as through road widening, the installation of traffic signs and lights, the construction of drainage systems, and the provision of complementary road facilities.

The Tonusu–Pendolo Road Section in Poso Regency, Central Sulawesi Province, serves as an important connector between Pamona Barat District and Pendolo District, covering a total length of approximately 58.5 km (Tonusu–Meko 16.10 km and Meko–Pendolo 42.40 km) with an average width of 4.50 meters. This road is of strategic importance as it provides access to the Poso Regency food production area and traverses the Pamona Nature Reserve as well as the Bancea Natural Tourism Park for a distance of 11.52 km. Based on the road condition data for Central Sulawesi Province, most sections of the Tonusu–Pendolo Road are classified as lightly or heavily damaged. Therefore, this study proposes a structural improvement plan for the Tonusu–Pendolo Road using flexible pavement design to accommodate current and future traffic demands.

In the maintenance process, road damage sometimes occurs before the design life is reached. This is caused by both human and natural factors. Natural factors affecting pavement quality include water, temperature variations, weather conditions, and others. Human factors include vehicle axle loads or freight tonnage that exceed capacity limits and an increasing volume of traffic. If these factors persist over time, they will cause significant road deterioration, ultimately harming all stakeholders.

Previous studies on pavement structure improvement have been widely conducted. For example, Setiawan et al. (2020) emphasized the importance of evaluating pavement capacity using the Bina Marga method on national road sections in West Java, showing that road deterioration was primarily caused by heavy vehicle overloading and the lack of periodic maintenance. However, their study mainly focused on technical aspects of traffic load without considering environmental conditions surrounding the road. Meanwhile, Susanti and Nugroho (2021) in South Sulawesi highlighted that environmental factors such as poor drainage and high rainfall significantly contributed to early pavement damage, but their research was limited to identifying causal factors without providing detailed pavement structure design solutions. These studies reveal a gap, namely the need for a comprehensive approach that not only evaluates pavement capacity but also proposes structural design improvements tailored to local traffic, subgrade, and environmental conditions.

Therefore, this study seeks to fill that gap by evaluating the existing condition of the Tonusu–Pendolo Road Section in Poso Regency using the Bina Marga flexible pavement design method, while proposing appropriate layer thicknesses based on subgrade CBR values and projected traffic loads. The objective of this study is to provide a more durable and context-specific road design solution, with practical benefits for local government in planning road maintenance programs and academic contributions to the development of civil engineering knowledge, particularly in transportation and pavement design.

RESEARCH METHOD

The research uses an applied engineering approach with a descriptive and quantitative analysis method. The descriptive method is applied to present the existing condition of the Tonusu–Pendolo Road Section, while the quantitative analysis is used to calculate pavement thickness and evaluate structural improvement requirements based on Indonesian flexible pavement design standards.

This study was conducted on the Tonusu–Pendolo Road Section in Poso Regency, Central Sulawesi Province, Indonesia. The road segment serves as an essential transportation link between Pamona Barat District and Pendolo District, passing through agricultural production areas as well as conservation zones such as the Pamona Nature Reserve and the Bancea Natural Tourism Park. The total length of the section is approximately 58.5 km, with an average pavement width of 4.50 m.

The data collection methods in this study involved both primary and secondary data. Primary data were obtained through a classified traffic survey conducted over a specified observation period to determine traffic volume and vehicle composition, a pavement condition survey through visual inspection to identify types and extents of damage such as cracks, potholes, rutting, and surface deformation, and soil investigations including field tests and sampling to determine subgrade properties such as California Bearing Ratio (CBR) values. Meanwhile, secondary data were collected from the Central Sulawesi Provincial Government in the form of road inventory and condition records, as well as topographic maps, climatic data, and references from previous studies and relevant literature on pavement design to support the analysis.

The research analysis process includes:

1. Traffic Data Analysis – Converting classified vehicle counts into Equivalent Standard Axle Loads (ESAL) using axle load factors according to Indonesian guidelines.
2. Subgrade Evaluation – Using CBR test results to determine subgrade strength classification.
3. Pavement Thickness Design – Applying the Indonesian Road Pavement Design Manual (Bina Marga Method) to determine layer thickness for the surface course, base course, and subbase course.
4. Structural Evaluation – Comparing existing pavement conditions with design requirements to identify the type of improvement needed (rehabilitation, overlay, or reconstruction).

RESULT AND DISCUSSION

Existing Road Condition

The Tonusu–Pendolo Road Section is a provincial road with a total length of approximately 58.5 km and an average width of 4.50 m. Based on the visual survey, the pavement surface condition is dominated by light to severe damage, including alligator cracking, raveling, potholes, rutting, and surface depressions. These damages reduce ride quality, compromise road safety, and accelerate further structural deterioration.

The primary causes identified are overloading of heavy vehicles, inadequate drainage, and environmental effects such as prolonged rainfall and temperature fluctuations. Additionally, the subgrade has shown localized weaknesses, leading to uneven settlement and surface failures.

Traffic Volume Analysis

Traffic counts were conducted for a continuous 3-day period, covering different time intervals to capture daily variations. The classified count included motorcycles, passenger cars, light trucks, medium trucks, and heavy trucks.

The recorded traffic volumes were converted into Equivalent Standard Axle Loads (ESAL) using load equivalency factors from the Indonesian Road Pavement Design Manual. The Design Traffic Load (W18) was then projected over the design period of 10 years, incorporating annual traffic growth rates.

Subgrade Evaluation

Field CBR tests were carried out at several representative points along the road section. The results ranged from 5% to 8%, indicating a fair to poor subgrade category according to Indonesian standards. This means that a thicker pavement structure is required to ensure durability and prevent premature failure.

Pavement Thickness Design

Using the Bina Marga Flexible Pavement Design Method, the required pavement layer thickness was determined based on the projected traffic load and measured subgrade CBR values.

Proposed Pavement Structure

1. Surface Course (AC-WC): 4 cm
2. Binder Course (AC-BC): 6 cm
3. Base Course (Aggregate Class A): 20 cm
4. Subbase Course (Aggregate Class B): 20 cm

This design ensures that the pavement can withstand the anticipated traffic load for the planned 10-year service life without significant structural failure.

The analysis shows that the current pavement structure is insufficient to support the increasing traffic volume, especially from overloaded heavy vehicles. The low subgrade CBR values necessitate additional base and subbase thickness to distribute loads effectively. Furthermore, drainage improvements are critical to prevent water infiltration, which is a major cause of pavement deterioration. Implementing the proposed structural upgrade will not only restore the road's functional condition but also extend its service life. However, enforcement of axle load regulations and regular maintenance are essential to ensure the long-term performance of the pavement.

CONCLUSION

Based on field surveys, data analysis, and flexible pavement design calculations, the Tonusu–Pendolo Road Section—a strategic provincial road in Poso Regency spanning approximately 58.5 km with an average width of 4.50 m—is currently in poor condition, exhibiting cracks, potholes, rutting, and surface deformation. Traffic growth, especially from heavy vehicles, has accelerated pavement deterioration, with projected Equivalent Standard Axle Loads (ESAL) for the next decade exceeding the capacity of the existing structure. Subgrade CBR values between 5–8% indicate fair to poor foundation strength, necessitating a stronger pavement design. The Bina Marga Flexible

Pavement Method recommends a multilayer structure consisting of a 4 cm Asphalt Concrete Wearing Course, 6 cm Binder Course, 20 cm Aggregate Class A base, and 20 cm Aggregate Class B subbase to adequately support future traffic. To prevent premature failure and ensure user safety and comfort, it is critical for local authorities to implement this design, enforce axle load limits, improve drainage, and establish routine maintenance programs. Future research should focus on evaluating the long-term performance of the proposed pavement structure under changing climate conditions and exploring sustainable materials and construction techniques suited to local environmental and traffic demands.

REFERENCES

Adugbila, E. J., Martinez, J. A., & Pfeffer, K. (2023). Road infrastructure expansion and socio-spatial fragmentation in the peri-urban zone in Accra, Ghana. *Cities*, *133*. https://doi.org/10.1016/j.cities.2022.104154

Aryan, Y., Dikshit, A. K., & Shinde, A. M. (2023). A critical review of the life cycle assessment studies on road pavements and road infrastructures. In *Journal of Environmental Management* (Vol. 336). https://doi.org/10.1016/j.jenvman.2023.117697

Brueckner, M., & Lederman, D. (2018). Inequality and economic growth: the role of initial income. *Journal of Economic Growth*, *23*(3). https://doi.org/10.1007/s10887-018-9156-4

de Abreu, V. H. S., Santos, A. S., & Monteiro, T. G. M. (2022). Climate Change Impacts on the Road Transport Infrastructure: A Systematic Review on Adaptation Measures. In *Sustainability (Switzerland)* (Vol. 14, Issue 14). https://doi.org/10.3390/su14148864

Halilintar, M. (2018). Cooperatives and economic growth in Indonesia. *European Research Studies Journal*, *21*(2). https://doi.org/10.35808/ersj/1027

Khanani, R. S., Adugbila, E. J., Martinez, J. A., & Pfeffer, K. (2021). The Impact of Road Infrastructure Development Projects on Local Communities in Peri-Urban Areas: the Case of Kisumu, Kenya and Accra, Ghana. *International Journal of Community Well-Being*, *4*(1). https://doi.org/10.1007/s42413-020-00077-4

Laila Hasyim Tambun, Delin Sea, Muhammad Zulfikar, Puti Andiny, & Safuridar Safuridar. (2023). The Influence of Infrastructure on Economic Growth in Indonesia. *Akuntansi*, *2*(4).

Nugraha, A. T., Prayitno, G., Situmorang, M. E., & Nasution, A. (2020). The role of infrastructure in economic growth and income inequality in Indonesia. *Economics and Sociology*, *13*(1). https://doi.org/10.14254/2071-789X.2020/13-1/7

Rivera, L., Baguec, H., & Yeom, C. (2020). A study on causes of delay in road construction projects across 25 developing countries. *Infrastructures*, *5*(10). https://doi.org/10.3390/infrastructures5100084

Safrita, S., Abbas, T., & Yurina, Y. (2021). THE EFFECT OF ECONOMIC GROWTH AND POVERTY ON INCOME INEQUALITY IN INDONESIA. *Journal of Malikussaleh Public Economics*, *4*(1). https://doi.org/10.29103/jmpe.v4i1.4792

Segui, P., Safhi, A. el M., Amrani, M., & Benzaazoua, M. (2023). Mining Wastes as Road Construction Material: A Review. In *Minerals* (Vol. 13, Issue 1). https://doi.org/10.3390/min13010090

Son, D., Chu, Y., & Lee, H. (2024). Roads as conduits for alien plant introduction and dispersal: The amplifying role of road construction in Ambrosia trifida dispersal. *Science of the Total Environment*, *912*. https://doi.org/10.1016/j.scitotenv.2023.169109

Trunzo, G., Moretti, L., & D'Andrea, A. (2019). Life cycle analysis of road construction and use. *Sustainability (Switzerland)*, *11*(2). https://doi.org/10.3390/su11020377

Wang, C., Lim, M. K., Zhang, X., Zhao, L., & Lee, P. T. W. (2020). Railway and road infrastructure in the Belt and Road Initiative countries: Estimating the impact of transport infrastructure on economic growth. *Transportation Research Part A: Policy and Practice*, *134*. https://doi.org/10.1016/j.tra.2020.02.009

Wubet, W. A., Burrow, M., & Ghataora, G. (2023). Risks affecting the performance of Ethiopian domestic road construction contractors. *International Journal of Construction Management*, *23*(4). https://doi.org/10.1080/15623599.2021.1902732