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Damage Assessment and Sustainable Manufacturing Solutions for the Bengras-Cinoyong Route

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Abstract

This research explores sustainable and innovative solutions for road maintenance, specifically focusing on the repair and improvement of the Bengras-Cinoyong route. The study investigates the causes of road deterioration, including excessive traffic loads, poor drainage systems, and material deficiencies. By reviewing existing literature, this research evaluates the potential of advanced materials such as fiberglass-reinforced recycled HDPE composites and polymer-modified asphalt to enhance road durability. Additionally, it examines modern manufacturing-based repair techniques, such as hot-mix asphalt blending, extrusion-based composite application, and spray coating technologies. The findings suggest that these materials and techniques offer significant advantages over conventional repair methods, including improved tensile strength, flexibility, and reduced maintenance costs. The study concludes by recommending pilot testing, long-term monitoring, and collaboration among stakeholders to implement these innovative solutions, aiming for sustainable and cost-effective road infrastructure management.

Keywords **:** *Road maintenance, fiberglass-reinforced HDPE, polymer-modified asphalt, road deterioration, manufacturing-based repair techniques*

INTRODUCTION

Road infrastructure plays a crucial role in economic growth, transportation efficiency, and public safety (Surbakti et al., 2022). However, road damage remains a persistent issue, especially on high-traffic routes such as the Bengras-Cinoyong road. Various factors contribute to road deterioration, including excessive vehicle loads, poor drainage systems, substandard construction materials, and environmental conditions. If not addressed effectively, road damage can lead to increased maintenance costs, traffic congestion, and safety hazards for road users (Khoirudin et al., 2021). Therefore, identifying sustainable and cost-effective repair solutions is essential for long-term infrastructure resilience (F. M. Dewadi, 2022). The following will be explained in figure 1 regarding the background of road damage.

Figure 1. Road damage that needs to be repaired (Source: Personal documentation)

One promising approach to improving road durability is the integration of advanced materials and modern manufacturing techniques (F. Dewadi et al., 2016). Previous studies have explored the use of composite materials, such as recycled high-density polyethylene (HDPE) reinforced with fiberglass, to enhance the mechanical properties of pavement structures (F. M. Dewadi, 2024). These materials offer improved tensile strength, flexibility, and resistance to environmental degradation compared to conventional asphalt mixtures (F. Dewadi & Amir, 2021). Additionally, the application of polymer-modified asphalt and other sustainable additives has been shown to extend the lifespan of road surfaces (F. M. Dewadi & Abduh Al-Afgani, 2021).

The selection of appropriate repair methods is also a critical factor in ensuring effective road maintenance (Nanda & Dewadi, 2024). Traditional road repair techniques, such as hot-mix asphalt (HMA) and cold recycling, have been widely used but often require frequent maintenance due to material limitations (Nanda et al., 2024). In contrast, modern manufacturing-based approaches, such as extrusion and spray coating technologies, offer innovative solutions that enhance road durability while reducing maintenance frequency and costs (F. M. Dewadi, Supriyadi, et al., 2024). The integration of these advanced techniques into road repair strategies has the potential to significantly improve infrastructure sustainability (F. M. Dewadi, 2023).

This study is conducted using a literature review approach, which involves analyzing previous research and case studies related to road damage, material innovations, and manufacturing-based repair methods (Kusmiwardhana et al., 2024). By reviewing existing studies, this research aims to evaluate the effectiveness of various road repair solutions and determine the feasibility of using fiberglass-reinforced recycled HDPE composites for improving the Bengras-Cinoyong road. Additionally, this study seeks to identify best practices in modern road maintenance and propose a sustainable framework for infrastructure improvement (Wibowo et al., 2024).

By leveraging insights from literature studies, this research aims to contribute to the development of more resilient, cost-effective, and environmentally friendly road maintenance solutions (Abbas et al., 2021). The findings are expected to provide valuable recommendations for policymakers, engineers, and stakeholders involved in road infrastructure management, ensuring that future road repair strategies incorporate advanced materials and efficient manufacturing technologies (Nurmiah et al., 2023).

METHOD

This research employs a literature study approach to analyze road damage issues and explore potential manufacturing-based repair solutions (F. M. Dewadi, Milasari, A, et al., 2023).

The study involves collecting and reviewing relevant literature from scientific journals, books, technical reports, and case studies (Yusaerah et al., 2022). The focus is on understanding the causes of road deterioration, the role of composite materials in road repair, and the effectiveness of various manufacturing techniques in improving road durability (Alfaris et al., 2022). By synthesizing previous research findings, this study aims to provide a comprehensive assessment of sustainable road maintenance strategies (Ratnadewi et al., 2023).

The first step in this research is identifying the primary causes of road damage (F. Dewadi, Puspita, et al., 2024). Literature on factors such as excessive traffic loads, environmental influences, poor drainage systems, and low-quality construction materials will be analyzed (Mustafa et al., 2023). Understanding these factors is crucial for determining the most suitable repair strategies (Yunus et al., 2023). Special attention will be given to the Bengras-Cinoyong road conditions, drawing comparisons with similar cases from previous studies. The next stage involves examining material innovations for road maintenance (Nugroho et al., 2023). This research will explore the potential of using fiberglass-reinforced recycled HDPE composites, polymer-modified asphalt, and other advanced materials in road construction and repair (Wiyono et al., 2023). Studies on the mechanical properties, thermal stability, and environmental benefits of these materials will be reviewed to assess their suitability for application in the Bengras-Cinoyong route. The goal is to identify materials that offer enhanced durability while promoting sustainability (Darmayani et al., 2023).

Following the material review, the study will focus on analyzing manufacturing-based road repair techniques (Purnomo & Sahabuddin, 2023). Various methods, including hot-mix asphalt blending, extrusion-based composite application, and spray coating technologies, will be evaluated for their efficiency and cost-effectiveness (F. M. Dewadi, Normansyah, Naibaho, et al., 2023). Literature on successful implementations of these techniques will be examined to determine their practical feasibility in addressing road damage (F. M. Dewadi, Pido, Issafira, et al., 2023). Comparisons between traditional and modern repair methods will be conducted to highlight the advantages of adopting advanced manufacturing approaches (F. Dewadi, Octavianti, Nanang, et al., 2023). Finally, the research will synthesize key findings and provide recommendations for improving road maintenance on the Bengras-Cinoyong route. The recommendations will focus on selecting the most suitable materials, implementing effective manufacturing-based repair techniques, and adopting long-term sustainable road maintenance practices (F. M. Dewadi, Nova, et al., 2024). These findings are expected to serve as a valuable reference for policymakers, engineers, and stakeholders involved in infrastructure management, ensuring the development of more durable and environmentally friendly road systems (N et al., 2024).

RESULT AND DISCUSSION

The analysis of road damage factors reveals that excessive traffic loads, environmental conditions, poor drainage, and low-quality construction materials are the primary contributors to road deterioration (F. M. Dewadi, Puspita, et al., 2024). Based on literature findings, these factors accelerate the formation of cracks, potholes, and surface deformations, reducing the lifespan of roads (Sugiyanto et al., n.d.). The Bengras-Cinoyong route serves as a case study to illustrate these issues, with observations showing significant structural damage due to high vehicle density and inadequate maintenance practices. Similar cases from previous studies highlight the urgency of implementing advanced repair strategies to enhance road durability and sustainability (Simatupang et al., 2013).

A review of material innovations indicates that fiberglass-reinforced recycled HDPE composites, polymer-modified asphalt, and other advanced materials offer promising solutions for road repair (Wibowo et al., 2023). Fiberglass-reinforced HDPE composites exhibit excellent mechanical properties, such as high tensile strength, impact resistance, and thermal stability, making them a viable alternative for road rehabilitation (F. M. Dewadi, Farahdiansari, Rochyani, et al., 2023). Studies on polymer-modified asphalt suggest improved flexibility, water resistance, and durability compared to conventional asphalt (F. M. Dewadi, Sriwahyuni, Edahwati, et al., 2023). The integration of these materials in road construction and maintenance could significantly enhance the performance of the Bengras-Cinoyong route while promoting environmental sustainability through the use of recycled materials.

The evaluation of manufacturing-based repair techniques highlights the effectiveness of hot-mix asphalt blending, extrusion-based composite application, and spray coating technologies (Alfianto et al., 2023). Hot-mix asphalt blending is widely used for its ability to provide a strong and uniform road surface (Dahri et al., 2023). Extrusion-based composite application, incorporating fiberglass-reinforced HDPE, ensures enhanced structural integrity and prolonged road lifespan (Nanda et al., 2023). Spray coating technologies further improve surface protection by reducing moisture infiltration and wear (F. M. Dewadi, Kristiana, La Ola, et al., 2023). Literature reviews demonstrate that these methods are more efficient and cost-effective compared to traditional repair approaches, emphasizing the need for their adoption in the Bengras-Cinoyong area.

Comparisons between traditional repair techniques and modern manufacturing-based approaches underscore the advantages of adopting innovative materials and processes (F. Dewadi, Kusmiwardhana, Hakim, et al., 2023). Traditional methods, such as patching and resurfacing, provide temporary solutions but often lead to recurring damage (F. M. Dewadi, Milasari, Hermila, et al., 2023). In contrast, advanced manufacturing techniques integrate durable composite materials, extending the service life of roads and minimizing maintenance costs (F. M. Dewadi, Wibowo, Mulyadi, et al., 2023). Case studies from other regions confirm that adopting these advanced approaches results in longer-lasting infrastructure with reduced environmental impact (Santosa et al., 2022).

CONCLUSION

This research employs a literature study approach to analyze road damage issues and explore potential manufacturing-based repair solutions. The study involves collecting and reviewing relevant literature from scientific journals, books, technical reports, and case studies. The focus is on understanding the causes of road deterioration, the role of composite materials in road repair, and the effectiveness of various manufacturing techniques in improving road durability. By synthesizing previous research findings, this study aims to provide a comprehensive assessment of sustainable road maintenance strategies.

The first step in this research is identifying the primary causes of road damage. Literature on factors such as excessive traffic loads, environmental influences, poor drainage systems, and low-quality construction materials will be analyzed. Understanding these factors is crucial for determining the most suitable repair strategies. Special attention will be given to the Bengras-Cinoyong road conditions, drawing comparisons with similar cases from previous studies.

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Finally, the research will synthesize key findings and provide recommendations for improving road maintenance on the Bengras-Cinoyong route. The recommendations will focus on selecting the most suitable materials, implementing effective manufacturing-based repair techniques, and adopting long-term sustainable road maintenance practices. These findings are expected to serve as a valuable reference for policymakers, engineers, and stakeholders involved in infrastructure management, ensuring the development of more durable and environmentally friendly road systems.

ADVICE

To improve road durability and sustainability, it is recommended to conduct pilot tests on the Bengras-Cinoyong route using fiberglass-reinforced recycled HDPE composites and polymer-modified asphalt. These materials have shown significant potential in enhancing road performance in similar studies, offering better strength, thermal stability, and resistance to environmental degradation. Testing these materials in real-world conditions will provide valuable data on their effectiveness under local traffic loads, weather conditions, and wear patterns, helping to refine their application for long-term use. Additionally, establishing collaboration between local governments, engineers, and material scientists will facilitate the integration of advanced materials and manufacturing techniques into current road maintenance strategies.

Long-term monitoring of the performance of these materials should be implemented after the pilot testing phase to track their effectiveness and longevity. Data on factors like surface wear, crack formation, and load resistance will offer valuable insights into the materials' durability and help identify areas that need improvement. Expanding the use of these materials to other regions experiencing similar road damage can provide broader benefits by reducing maintenance costs and improving infrastructure resilience. Further research into new composite materials and manufacturing techniques, including exploring recycled construction waste, can continue to advance sustainable and cost-effective solutions for road maintenance.

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