Volume 4, No. 6 September 2025
p-ISSN 2980-4868| e-ISSN 2980-4841
https://ajesh.ph/index.php/gp

Comparative Analysis of Concrete And Asphalt Pavement Improvements in Terms of Cost and Time on the Bringkang–Lampah Road, Gresik Regency

Syarifuddin, Wateno Oetomo, Risma Marleno
Universitas 17 Agustus 1945 Surabaya, Indonesia
Email: riff.syarifuddin@gmail.com, wateno@untag-sby.ac.id, marleno.ts@gmail.com

ABSTRACT

The southern region of Gresik Regency is undergoing rapid development in the residential, agricultural, and industrial sectors, necessitating improved road infrastructure to support mobility and logistics. This study provides a comparative analysis of concrete (rigid) and asphalt (flexible) pavement improvements on the Bringkang–Lampah road segment from both cost and time perspectives. It aims to provide valuable insights for sustainable and cost-effective infrastructure planning, assisting stakeholders in making informed decisions regarding pavement selection to ensure long-term durability, efficiency, and economic viability. Using a quantitative case study approach, traffic projections were calculated for 20- and 40-year design lives with a 3.5% annual growth rate, while pavement designs followed Indonesian standards: Pd T-14-2003 for rigid and MDPJ 2017 for flexible pavement. The cost analysis accounts for construction expenses and periodic maintenance while optimizing the use of existing pavement for efficiency. The findings reveal that, while concrete pavements have higher initial costs and longer construction times, they provide a longer service life and lower long-term maintenance costs, making them more economical for heavy traffic. Conversely, asphalt pavements are quicker and cheaper to construct but require more frequent maintenance, potentially increasing long-term expenditures. The study implies that concrete pavement is more suitable for heavily trafficked routes prioritizing lifecycle cost efficiency, whereas asphalt is preferable for projects requiring rapid deployment.

Keywords: Rigid Pavement, Flexible Pavement, Cost Analysis, Traffic Projection, Infrastructure Planning

INTRODUCTION

The development of road infrastructure is a vital element in supporting the economic growth of a region (Nawir et al., 2023; Ng et al., 2019). In the southern part of Gresik Regency, the simultaneous increase in residential, agricultural, and industrial areas has triggered the need for more reliable and durable road infrastructure. The Bringkang–Lampah road section is one of the main accesses connecting production and distribution areas. However, damaged road conditions slow down mobility and increase vehicle operating costs (Ministry of PUPR, 2017).

In the context of road infrastructure planning, the selection of pavement types is a crucial factor. Two types of pavements that are commonly used are rigid pavements and flexible pavements (Hardiyatmo, 2015; Rumahstruktur.co.id, 2020). Each has advantages and disadvantages in terms of structure, durability, initial construction costs, and long-term maintenance costs.

Flexible asphalt-based pavements are known to be more adaptable and faster to construct. The 2017 Road Pavement Design Manual (MDPJ) provides guidelines for designing asphalt layer thickness by considering daily traffic, CBR, and vehicle growth factors (Asidin, 2021; Ministry of PUPR, 2017). However, this type of pavement requires routine maintenance and has a shorter service life than rigid pavement (Assa et al., 2022). In contrast, rigid pavements using cement concrete tend to be stronger and more resistant to heavy traffic loads. Although the initial cost is higher and construction time is longer, the service life is approximately twice that of asphalt (Nauval & Narendra, 2023; Department of Settlement, 2003). Based on calculations by Ibrahim & Narendra (2023), concrete pavements can be more economical in the long term. A study by Lelepadang et al. (2020) showed that the cost of rigid pavement on Jalan Prof. M. Yamin was 1.7% higher than flexible pavement, but it had a design life twice as long. Similarly, Prasojo & Narendra (2023) noted that concrete is more resistant to extreme temperatures and heavy loads.

Adhita Maharani (2018) conducted a comparison between the two types of pavements on the Prigi-Popoh Coast Highway section, and the results supported the long-term efficiency of rigid pavement. This aligns with the findings of Fajarianto et al. (2023), who used the Austroad and Bina Marga methods to analyze the Purworejo-Senduro road section. In a local study, Ridwan & Romadhon (2019) assessed that rigid pavement is very suitable for main roads connecting regions due to its strength. Firmansyah et al. (2022) also emphasized that rigid pavement increases the structural capacity of roads in Jambi City.

Several other studies, such as Mahardika et al. (2021), compared the costs of road construction with various pavement types and concluded that although paving blocks are cheaper, rigid pavement remains the best choice for heavy transportation routes. According to Aditiya & Siswoyo (2020), the thickness and cost of concrete on Jalan Babat - Batas Jombang require large investments, but the benefits are comparable to its long life and minimal maintenance. This is consistent with the study of Kurniawan & Djunaidi (2020) on the Sungai Pinang-Pantai Mempanak section.

Prasetya et al. (2023) added that, on the access road to Rusun PPI TPI Romokalisari, long-term efficiency is the main reason for choosing concrete pavement. McKinsey & Company (2020) emphasized that the effectiveness of road infrastructure management is highly dependent on the pavement strategy used. International studies from AASHTO (1993) and Austroad (1987) provide scientific frameworks emphasizing that pavement structures need to be adjusted to traffic loads, soil conditions, and design life. Therefore, adjusting pavement design by considering existing conditions is important.

Azizi Muhammad Nasution (2019) emphasized that pavement thickness must be adjusted according to road class and traffic volume, while Lorinanto & Siswoyo (2023) used the 2017 MDPJ guidelines to determine the optimal design on Sawunggaling Highway. Putri Zayu et al. (2022) revealed that although the cost of flexible pavement is slightly lower in Sawah Lunto

City, rigid pavement remains superior in terms of strength and service life. Sutapa et al. (2022) stated that the project in Celukan Bawang showed the long-term economic value of concrete. In public procurement, the sites Pengadaan.web.id (2020) and Tekniksipil.id (2020) explain that pavement selection depends heavily on functional needs and long-term cost efficiency. Meanwhile, Sewaalatberat.co.id (2020) provides explanations of the component structures of both pavement types. Redasamudera.id (2020) explains that rigid pavement has a high modulus of elasticity, while flexible pavement relies on layer-by-layer flexibility. This aligns with Rumahstruktur.co.id (2020), which states the importance of selecting materials according to road function.

In the case of the Bringkang–Lampah section, the existing structure consisting of paving blocks has shown damage, so using the still-good base layer is an efficiency strategy (Mutuutamageoteknik.co.id, 2022). Considering all references, it is important for this study to provide recommendations based on traffic data, layer thickness, and construction and maintenance costs.

Based on the description above, the focus of the problem in this study is how to determine the Average Daily Traffic (LHR) levels for the next 20 and 40 years on the Bringkang–Lampah road section, Gresik Regency, as a basis for projecting traffic loads that will affect pavement design. In addition, an analysis is needed regarding the dimensions of concrete and asphalt pavements if utilizing the existing pavement structure for cost and material efficiency. Furthermore, it is necessary to compare construction and maintenance costs for the two types of pavements to obtain the most economical and sustainable alternative to support infrastructure development in the area.

The selection of appropriate pavement types is a critical decision in road infrastructure development, heavily influenced by localized traffic patterns, soil conditions, and economic constraints. While numerous studies have compared rigid and flexible pavements, a significant research gap exists in conducting a holistic, long-term lifecycle cost analysis that integrates detailed traffic projections—specifically for 20- and 40-year horizons—with the strategic use of existing pavement structures, particularly within the context of Indonesia's evolving national design standards. Many previous comparisons have focused on initial construction costs or structural design in isolation, often neglecting the compounded impact of maintenance frequency and the critical trade-off between initial project duration and long-term fiscal sustainability. This study aims to address this gap by providing an integrated evaluation framework tailored to the specific conditions of regional roads in Indonesia, offering a more nuanced and actionable decision-making tool for engineers and policymakers.

The urgency of this research is underscored by rapid development in the southern region of Gresik Regency, where increasing residential, agricultural, and industrial activities are placing unprecedented demands on the Bringkang–Lampah road. The current degraded pavement condition impedes mobility, elevates vehicle operating costs, and ultimately constrains local economic growth. Furthermore, with public infrastructure investments under intense scrutiny for efficiency and accountability, there is a pressing need to identify the most cost-effective and durable pavement solution that minimizes long-term public expenditure while ensuring reliable service. Timely and evidence-based infrastructure planning is therefore not merely a technical exercise but a crucial driver for regional socio-economic development.

The novelty of this research lies in its application of a dual-period traffic projection model (20 and 40 years) aligned with the latest Indonesian design manuals—MDPJ 2017 for flexible pavement and Pd T-14-2003 for rigid pavement—to perform a comparative lifecycle cost analysis. Furthermore, it introduces a practical dimension by incorporating the potential reuse of existing in-situ pavement layers, a strategy often advocated but rarely quantified in terms of its direct impact on both material cost savings and construction time reduction. This approach moves beyond theoretical design to deliver empirically grounded, context-specific insights that are novel for secondary road projects in Indonesia.

The primary purpose of this study is to conduct a comprehensive comparative analysis of concrete and asphalt pavement for the Bringkang–Lampah road, specifically evaluated from the perspectives of total financial outlay—encompassing both construction and maintenance costs—and project implementation time. This overarching aim is achieved through several specific objectives: to project future traffic loads (LHR and ESA) for 20- and 40-year design lives; to design the required pavement thickness for both alternatives in compliance with national standards while optimizing the use of the existing structure; and to meticulously estimate and compare the total initial and lifecycle costs alongside the construction time required for each option.

Ultimately, the benefits of this research are multifarious. It provides local government agencies and road authorities with a robust, data-driven basis for selecting the most economically efficient and technically sound pavement solution, ensuring that limited public funds are allocated for maximum long-term benefit. For the engineering community, it contributes to the practical application and validation of national pavement design manuals in real-world scenarios. The findings are expected to serve as a valuable reference for similar infrastructure projects across Indonesia, promoting sustainable, cost-effective, and context-aware road development strategies that balance immediate needs with future resilience.

METHOD

This research was conducted on the Bringkang – Lampah road section, Gresik Regency, East Java Province. This location was chosen because it has a fairly high level of traffic growth and has experienced a decline in the quality of existing pavements. The research was conducted over a period of three months, starting from January to March 2025. Research activities include field surveys, technical data collection, and laboratory analysis to support technical pavement planning. Survey and data collection activities were carried out directly in the field to obtain accurate primary data. In addition, this research is also supported by secondary data from the local Public Works Department and other relevant technical documents. The geographical and climatic conditions of the research area are also considered to support the accuracy of the planning results. Therefore, this location is considered representative for a comparative study of pavement types.

This study uses two main types of data, namely primary data and secondary data. Primary data includes the results of traffic surveys, soil tests using the Dynamic Cone

Penetration (DCP) method, and visual observations of existing pavement conditions. Secondary data is obtained from previous technical reports, pavement design standards, and supporting literature from civil engineering journals and books. The combination of these two types of data allows for comprehensive planning. Traffic data is used to project LHR for the next 20 and 40 years with a growth rate of 3.5% per year. The CBR value is calculated based on DCP test data to determine the bearing capacity of the base soil. This data is the main basis for determining the dimensions of the pavement layer, both for concrete and asphalt structures. With this approach, the planning carried out is more accurate and in accordance with field conditions.

Pavement planning is carried out using two approaches, namely the 2017 Road Pavement Design Manual (MDPJ) method for flexible pavements and Pd T-14-2003 for rigid pavements. The MDPJ method takes into account the average daily traffic factor, the CBR value of the subgrade, and the design age of the road. Meanwhile, the Pd T-14-2003 method considers the stiffness of the concrete, environmental factors, and the thickness of the concrete slab required. Both methods have been commonly used in technical practice in Indonesia and are in accordance with national standards. The planning steps include calculating the equivalent traffic load (ESA), selecting the layer thickness based on graphs and standard formulas, and evaluating the efficiency of the pavement structure. For flexible pavements, the AC-WC, AC-BC, and AC-Base surface layers are used. In rigid pavements, the structure consists of a concrete slab, a subbase layer, and subgrade. This process ends with a comparison between the two alternatives based on structural and economic efficiency.

RESULT AND DISCUSSION

Average Daily Traffic Projection (ADR)

Average Daily Traffic (ADR) projections are conducted to determine the traffic load that will be served by the Bringkang – Lampah road section in the next 20 and 40 years. Based on existing traffic data of 1,985 vehicles per day and a growth rate of 3.5% per year, an ADR projection is conducted using the geometric growth formula. The results show that the ADR in the 20th year reached 56,133 vehicles per day and in the 40th year it was 167,829 vehicles per day. This figure is the main basis for planning the thickness of the pavement layer to ensure the road service life is in accordance with technical standards.

This increase in traffic volume illustrates the urgency in designing road pavements that are able to withstand long-term heavy loads. High daily traffic will result in significant equivalent axle loads (ESA5). Therefore, the ESA5 parameters are the main reference in determining the pavement structure, both flexible and rigid. This projection also shows the need for pavement with resistance to deformation and structural damage.

The ESA5 calculation takes into account the percentage of heavy vehicles and the level of traffic growth during the design life. The results show that the total ESA5 for the 20-year age is 3,962,236 and for the 40-year age is 6,832,128. This value indicates the high pressure of traffic loads on the designed road structure. Therefore, the selection of pavement types must consider long-term load resistance.

Large traffic loads also have implications for the frequency of road maintenance. Roads that are not designed to receive large loads will quickly experience a decline in quality. In this case, the design life analysis is important to determine when maintenance interventions should be carried out. The LHR and ESA5 projections are the technical basis for formulating the pavement layer thickness design.

By looking at the results of this projection, it can be concluded that the Bringkang - Lampah road requires a strong, durable, and cost-effective pavement structure in the long term. Therefore, the next stage is to design the pavement structure using the MDPJ 2017 and Pd T-14-2003 methods. This design will adjust to the traffic data and soil bearing capacity that have been obtained. The results of these design calculations will be the main comparison in the cost and effectiveness analysis.

Comparison of Thickness and Cost of Concrete and Asphalt Pavement

The thickness design results show that the flexible pavement structure consists of a 4 cm AC-WC layer, 6 cm AC-BC, 7 cm AC-Base, and 10 cm LPA. Meanwhile, the rigid pavement has a 25 cm thick concrete slab with an additional 10 cm lean concrete and 10 cm LPA. The design considers a CBR value of 7,5% and a 20-year ESA projection to ensure structural durability. This thickness reflects the need for a structure that is proportional to the predicted traffic load. In terms of initial construction costs, flexible pavement costs Rp22,499,375,540.00 while rigid pavement costs Rp25,167,354,426.00. The cost difference of Rp2,667,978,886 shows that concrete pavement is indeed more expensive in the initial stage. However, when calculated in the long term, concrete has lower maintenance costs. This difference is key in the analysis of life cycle cost efficiency.

Table 1. ESA5 20-year calculation

No	Vehicle Type	Gol.	LHR (Vehicle/Day)	VDF 5 Actual	VDF 5 Normal	Total ESA5 Actual	Total ESA5 (Normal) 20 years
1.	Medium Truck (Two Axles Four Wheels)	6a	103	0,50	0,50	9.399	265.794
2.	Large Truck (Two Axles Six Wheels)	6b	75	9,20	5,10	125.925	3.561.119
				135.324			3.826.913
	ESA5 20 years						3.962.236

The table shows the breakdown of total costs over 20 years, including more frequent periodic maintenance on flexible pavements. Concrete pavements only require one minor rehabilitation during the period, while asphalt pavements require overlay and patching at least twice. Thus, the cumulative cost of flexible pavements is higher than concrete after 20 years. This finding indicates that concrete is more financially efficient in the long run.

Furthermore, in terms of implementation time, flexible pavements require 14 days while rigid pavements require 195 days. This time difference is due to the concrete curing process which requires additional time before the road can be used. The longer processing time on concrete is a constraint in projects with a target of rapid opening. However, in strategic infrastructure projects, strength and longevity remain a priority.

Finally, this comparison concludes that the choice of pavement type should be based on long-term traffic needs, environmental conditions, and total cost efficiency. Flexible pavements are more suitable for light to moderate traffic with the need for rapid road opening. Meanwhile, rigid pavements are more ideal for main routes serving heavy and intensive traffic. Therefore, a thorough evaluation needs to be done before making a final choice.

The results of the study indicate that the differences in technical characteristics and costs between concrete and asphalt pavements greatly influence planning decisions. Concrete structures provide longer service life and lower maintenance costs than asphalt. Although the initial cost is higher, long-term savings make concrete an economically profitable choice. This is in line with the findings of Lelepadang et al. (2020) and Ibrahim & Narendra (2023) who stated the efficiency of concrete investment.

Increasing traffic conditions require pavements that can withstand heavy loads for a long time. From the results of the LHR and ESA projections, flexible pavements may not be strong enough to withstand vehicle loads over a period of 40 years without major repairs. Therefore, concrete structures are an ideal alternative to avoid premature damage. This finding is reinforced by the studies of Assa et al. (2022) and Adhita Maharani (2018) who also emphasize the advantages of concrete in heavy road projects.

However, the final decision must still consider non-technical factors such as implementation time, budget, and urgency of road opening. For projects with time and budget constraints, flexible pavements can still be a practical solution. This is especially true for local roads or temporary access roads. Therefore, flexibility in decision-making is needed in road planning practices.

Life cycle cost analysis provides a more complete picture in evaluating the efficiency of both types of pavements. The initial construction cost is only one component of the total cost that will be incurred during the service life of the road. Therefore, a holistic approach must be used to consider all aspects of the cost including rehabilitation and routine maintenance. This finding strengthens the arguments put forward by Mahardika et al. (2021) and Prasojo & Narendra (2023).

Comparison of implementation time also shows that construction efficiency can be an important consideration in dense projects. If the main target is to open the road in a short time, then asphalt pavement is the superior choice. However, in projects with a long-term orientation, concrete pavement is superior in terms of durability and structural stability. This is in accordance with the guidelines described in Pd T-14-2003 and MDPJ 2017. Overall, the results and discussion of this study provide a scientific basis for making appropriate technical decisions in planning the improvement of the Bringkang - Lampah road. The empirical data obtained have shown that although there are significant differences in terms of cost and time, both have advantages according to the context of their use. Therefore, the final recommendation must refer to the specific needs of the project and long-term considerations in terms of economic and technical performance.

CONCLUSION

Based on a comprehensive lifecycle analysis, selecting between concrete (rigid) and asphalt (flexible) pavement for the Bringkang–Lampah road involves balancing initial costs against long-term value amid significant projected traffic growth. Asphalt pavement offers lower upfront costs and faster construction, making it suitable for budget-sensitive or rapid-deployment projects. However, concrete pavement proves to be the more economical option over a 40-year lifespan due to its superior durability and reduced maintenance needs. Incorporating the existing pavement structure improves cost efficiency for both alternatives, highlighting the importance of thorough condition assessment before design. Thus, concrete is preferable for heavy-traffic routes prioritizing lifecycle cost savings, while asphalt fits projects emphasizing quick implementation. Future research should expand this analysis by integrating a comparative Life Cycle Assessment (LCA) to quantify environmental impacts such as carbon footprint and energy use over each pavement's lifespan and examine their performance under local environmental stressors like high rainfall and temperature fluctuations. Additionally, adopting reliability-based design models that address material and load uncertainties and testing these approaches across diverse road types and soil conditions would enhance the development of more robust, sustainable, and cost-effective national infrastructure planning guidelines.

REFERENCES

Adhita, M. (2018). Perbandingan perkerasan kaku dan perkerasan lentur (Studi kasus ruas Jalan Raya Pantai Prigi–Popoh Kab. Tulungagung).

Aditiya, R. E., & Siswoyo, S. (2020). Perencanaan rigid pavement dan rencana anggaran biaya di Jalan Babat–Batas Jombang Kabupaten Lamongan.

Asidin. (2021). Perencanaan tebal perkerasan lentur jalan dengan menggunakan metode manual desain perkerasan jalan pada Kelurahan Lakambau Kecamatan Batauga Kabupaten Buton Selatan.

Assa, T. F., Palenewen, S. C. N., & Waani, J. E. (2022). Perbandingan analisa tebal perkerasan lentur (flexible pavement) dan perkerasan kaku (rigid pavement) terhadap rencana anggaran biaya.

Austroad. (1987). *Pavement design: A guide to the structural design of road pavements.* Austroad Incorporated.

Azizi, M. N. (2019). Perbandingan tebal perkerasan terhadap kelas jalan.

Fajarianto, D. Y., Poerwanto, J. A., & Ratnaningsih, D. (2023). Perbandingan perkerasan kaku dengan metode Bina Marga 2017 dan Austroad pada Jalan Raya Purworejo–Senduro Kabupaten Lumajang.

Firmansyah, R., Das, A. M., & Dony, W. (2022). Perencanaan rigid pavement pada rekontruksi kapasitas struktur di ruas Jalan Bensol Kota Jambi.

Hardiyatmo, H. C. (2015). *Perancangan perkerasan jalan dan penyelidikan tanah.* Yogyakarta: Gadjah Mada University Press.

Ibrahim, N. A. (2023). Perbandingan perkerasan kaku dan perkerasan lentur berdasarkan biaya dan umur rencana (Studi kasus Lot-3 Jembatan Kretek 2 Bantul).

Kamil, F., Setiawan, A., & Purnomo, J. (2023). Perencanaan perkerasan kaku (rigid pavement) pada kerusakan Jalan Wolter Monginsidi.

Kurniawan, H., & Djunaidi. (2020). Studi perbandingan konstruksi perkerasan lentur (flexible pavement) dan perkerasan kaku (rigid pavement) ditinjau dari biaya: Studi kasus

peningkatan kualitas Jalan Sungai Pinang–Pantai Mempanak Kabupaten Lingga.
Lelepadang, S., Nuhun, R., Nasrul, N., & Ahmad, S. N. (2020). Analisis perbandingan biaya konstruksi perkerasan kaku (rigid pavement) dan perkerasan lentur (flexible pavement) (Studi kasus: Jalan Prof. M. Yamin, Kelurahan Puuwatu, Kota Kendari).
Lorinanto, W., & Siswoyo, S. (2023). Perencanaan tebal perkerasan kaku pada Jalan Raya Sawunggaling Kabupaten Sidoarjo menggunakan metode Manual Desain Perkerasan Jalan 2017.
Mahardika, V., Mudiyono, R., & Soedarsono, S. (2021). Perbandingan konstruksi dan biaya untuk struktur perkerasan lentur, kaku, dan paving blok pada Jalan Pantai Utara Flores.
McKinsey & Company. (2020). *Improving the delivery of road infrastructure across the world.* McKinsey & Company.
Mutuutamageoteknik.co.id. (2022). Jenis perkerasan jalan raya dan penjelasan lengkapnya. Retrieved from https://www.mutuutamageoteknik.co.id
Nauval, I. M., & Narendra, A. (2023). Perbandingan perkerasan kaku dan perkerasan lentur berdasarkan biaya dan umur rencana.
Nawir, D., Bakri, M. D., & Syarif, I. A. (2023). Central government role in road infrastructure development and economic growth in the form of future study: the case of Indonesia. *City, Territory and Architecture*, *10*(1), 12.
Pengadaan.web.id. (2020). Mengenal jenis-jenis perkerasan jalan, perbedaan dan kelebihannya masing-masing. Retrieved from https://www.pengadaan.web.id
Prasojo, G., & Narendra, A. (2023). Analisis perbandingan tebal perkerasan kaku dan perkerasan lentur metode MDPJ 2017.
Prasetya, E. J., Marleno, R., & Tjendani, H. T. (2023). Analisis biaya investasi perkerasan lentur dan perkerasan kaku (Studi kasus pada ruas jalan akses Rusun PPI–TPI Romokalisari Surabaya).
Putri, Z. W., Vitri, G., Herman, H., & Fadel, R. (2022). Perbandingan konstruksi perkerasan lentur dan perkerasan kaku pada Jalan Gulang-Gulang Dusun Koto Kota Sawah Lunto Sta 0+000–0+500 km.
Redasamudera.id. (2020). Definisi perkerasan kaku menurut para ahli. Retrieved from https://www.redasamudera.id
Ridwan, A., & Romadhon, F. (2019). Analisis perencanaan perkerasan kaku (rigid pavement) Jalan Plosoklaten–Gedangsewu Kabupaten Kediri.
Rumahstruktur.co.id. (2020). Apa itu perkerasan jalan? Ini pengertian dan jenis-jenisnya. Retrieved from https://www.rumahstruktur.co.id
Sewaalatberat.co.id. (2020). Perkerasan lentur (flexible pavement): Mengenal struktur perkerasan jalan aspal. Retrieved from https://www.sewaalatberat.co.id
Sutapa, I. K., Wirahaji, I. B., & Ariadi, I. M. G. (2022). Analisis perbandingan perkerasan kaku dan perkerasan lentur pada proyek peningkatan Jalan Celukan Bawang–Pelabuhan.
Tekniksipil.id. (2020). Pelaksanaan perkerasan lentur: Menjelajahi fleksibilitas dan ketahanan jalan. Retrieved from https://tekniksipil.id