


Rigid Pavement Engineering of Lake-Musi Rawas Intersection Road Based on 2024 Pavement Design Manual

Rendi Nopradego¹, Saloma², Arie Putra Usman³

Program Studi Program Profesi Insinyur (PSPPI), Fakultas Teknik, Universitas Sriwijaya, Kota Palembang, Indonesia

Article Info	ABSTRACT
<p>Keywords: Aggregate, Low Traffic, Thick Plate, Thin Concrete.</p>	<p>Roads are one of the important elements to improve community economic facilities and infrastructure based on resources, as well as support regions in overcoming rural and sub-district isolation in Musi Rawas Utara Regency (Muratara). The Simpang Lake - Musi Rawas Boundary Road Section is one of the main connecting sections for the community to go to the plantation location and is a priority area in the plantation area. Considering that this section is a priority road section, planning is needed on the Simpang Lake – Musi Rawas Boundary road section using the 2024 Pavement Design Manual. The planned age of the Simpang Lake - Musi Rawas Boundary road section is 20 years with a CBR value of 7.85% JSKN plan of 64,295.49 units, the length of the road tested is 4,800 km. The results obtained are the design of concrete design with a low traffic category with a concrete slab thickness of 200 mm, a thin concrete thickness of 100 mm, an aggregate foundation layer with a thickness of 150 mm and has a Tie Bar with a transverse joint distance of 4.00 m.</p>
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INTRODUCTION

Road infrastructure plays a crucial role in supporting economic activity, social connectivity, and equitable regional development. In remote areas such as North Musi Rawas Regency (Muratara), the availability of proper roads is a key factor in linking communities to economic centers, including plantations and markets. Government Regulation No. 34 of 2006 classifies roads as public infrastructure that must be managed professionally and in accordance with their designated functions. Additionally, Law No. 38 of 2004 on Roads mandates that road management should support inter-regional connectivity. However, many road segments in priority areas still lack adequate pavement structures, which reduces accessibility for local residents. The Simpang Lake – Batas Musi Rawas road segment is a clear example of this issue. This road serves as a vital route connecting rural communities to plantations and agricultural distribution points, yet it has not received sufficient attention in terms of pavement planning. Therefore, implementing modern road design methods is essential for improving infrastructure quality and accelerating regional development (National Standardization Agency, 2003; North Musi Rawas Regent Decree, 2023).

Technical road planning aims to develop pavement structures that align with traffic conditions, soil characteristics, and long-term user needs. According to the 2024 Pavement Design Manual (MDP), this process involves calculating the design life, average daily traffic (ADT), California Bearing Ratio (CBR), and designing pavement layers consisting of rigid concrete, lean concrete, and aggregate base layers. Accurate dimensioning of the pavement structure significantly affects the durability and budget efficiency of the project (Farid, 2013). Previous studies have shown that errors in determining pavement type and thickness often lead to early road failures (Pramudita, 2016). Thus, road pavement design must be based on current traffic data and local geotechnical conditions. The 2024 MDP offers an updated approach based on real-world needs and the latest research in transportation engineering (Pavement Design Manual, 2024). For this segment, adjustments based on the low-traffic category serve as the foundation for determining the design specifications.

The South Sumatra region, including Muratara Regency, presents unique geographical challenges with varied soil conditions and high rainfall intensity. Rigid pavement design emerges as a suitable alternative to enhance road resilience against traffic loads and environmental factors. Rigid pavement is known for its superior resistance to plastic deformation and longer service life compared to flexible pavement (Caddha, Chauhan, & Chawla, 2017). Although the initial investment is relatively higher, this type of pavement is more cost-effective in the long term when assessed through life cycle cost analysis (Hardianto, 2015). This makes rigid pavement highly suitable for primary roads in plantation areas, where agricultural transport vehicles regularly pass. Given the low but consistent traffic volume, applying rigid pavement on the Simpang Lake – Batas Musi Rawas segment is a strategic solution for maintaining road quality while minimizing maintenance frequency.

Determining pavement structure dimensions is heavily influenced by the California Bearing Ratio (CBR), which reflects the soil's load-bearing capacity. The CBR value of 7.85% for the Simpang Lake – Batas Musi Rawas segment indicates a moderately supportive subgrade, allowing for the implementation of pavement with moderate thickness. Additionally, the daily volume of commercial vehicles on this road is only 20 ESALs per day, classifying it as a low-traffic segment (Pavement Design Manual, 2024). According to the 2017 MDP technical guidelines, road segments with ADT < 50 commercial vehicles per day and MST < 8 tons require pavement structures with 150–200 mm concrete slab thickness and 100 mm lean concrete base (Pd T-14-2003; MDP-2017). This planning approach also adheres to SNI standards and includes parameters such as tie bar spacing and material quality. With an accurate design approach, the road structure quality can be improved while ensuring long-term safety and comfort for road users (National Standardization Agency, 2003).

The Simpang Lake – Batas Musi Rawas road segment holds strategic significance within the local road network system as outlined in the North Musi Rawas Regent Decree of 2023. This road is crucial not only for inter-village connectivity but also for supporting the distribution of plantation products to regional markets. According to the Muratara Regency Road Network Map, this segment connects several local economic centers, highlighting the need for a strong and durable road structure to ensure smooth logistics and community

mobility (Muratara Public Works and Spatial Planning Office, 2024). Furthermore, from a national development perspective, improving road infrastructure in peripheral areas is part of a broader strategy to achieve equitable development and reduce poverty. Therefore, the proposed rigid pavement design must address the need for long-term connectivity and efficient transportation in the region (Presidential Regulation No. 12 of 2021; Law No. 38 of 2004).

Technical road pavement studies emphasize not only structural aspects but also cost efficiency and ease of implementation. Research by Farid (2013) indicates that selecting an appropriate pavement structure can reduce annual maintenance costs by up to 30%. For local road projects such as those in Muratara, this is particularly important due to limited regional budgets. Hence, the proper combination of lean concrete, concrete slabs, and aggregate bases should be carefully determined based on actual traffic data. This data-driven approach aligns with sustainable construction procurement principles as regulated by Presidential Regulation No. 16 of 2018 and its amendments. Consequently, road infrastructure projects in underdeveloped areas can still meet national quality standards without compromising budget efficiency (Regulation of the National Public Procurement Agency, 2015).

Given the urgency and background described above, this study aims to design a rigid pavement structure for the Simpang Lake – Batas Musi Rawas road segment using the 2024 Pavement Design Manual as a reference. The specific objectives of this study are: (1) To determine the traffic characteristics of the Simpang Lake – Batas Musi Rawas segment based on ADT and ESAL data, (2) To calculate the appropriate thickness of concrete slabs, lean concrete, and aggregate base layers based on CBR values and traffic volume, and (3) To develop pavement structure design recommendations that are effective, efficient, and nationally standardized. The results of this study are expected to serve as a technical reference for relevant agencies in planning and constructing durable, cost-effective road infrastructure that effectively supports local community activities and regional economic growth.

METHODS

The method of information collection is a systematic approach to gathering and measuring data related to the desired research variables, enabling researchers to answer relevant questions and assess the results accurately.

Primary data refers to data obtained directly from field conditions at the Simpang Lake–Batas Musi Rawas road segment. The researcher collects this data through surveys and observations, allowing for accurate measurements that reflect the actual conditions of the road segment.

Secondary data is obtained from relevant stakeholders or institutions that hold the necessary information, such as the Public Works and Spatial Planning Office of North Musi Rawas Regency. One example of secondary data used in this study is the Decree of the Regent of North Musi Rawas Number: /KPTS/DPUPR/MRU/2023 concerning the Designation of Road Segment Status as a Regency Road for North Musi Rawas in the Year 2023, as presented in Table 1.

Table 1. Road sections according to their status as district roads

No. ROAD	NAME OF THE ROAD	KECAMATAN VIOLATED ROAD	LENGTH (Km)
K.001	SURULANGUN – LUBUK MAS	Rawas Ulu	23,4
K.002	MUARA RUPIT – KARANG DAPO	Rupit-Karang Dapo	15,07
K.003	BERINGIN MAKMUR II – SIMPANG BELANI	Rawas Ilir	14,8
K.004	SIMPANG BELANI – AIR BENING	Rawas Ilir	13,8
No. ROAD	NAME OF THE ROAD	KECAMATAN VIOLATED ROAD	LENGTH (Km)
K.005	KETAPAT BENING – BATAS MUSI BANYUASIN	Rawas Ilir	8,4
K.006	MUARA RUPIT – LAWANG AGUNG	Rupit	3,7
K.007	SPG. SURULANGUN – SPG. POLSEK RAWAS ULU	Rawas Ulu	4,7
K.008	KARANG DAPO – SETIA MARGA – BATAS MURA	Karang Dapo	18,9
K.009	KARANG ANYAR – DANAU RAYA	Rupit	3,8
K.010	SUKAMENANG – TANJUNG AGUNG	Karang Jaya	7,14
K.011	KERANI JAYA – DANAU RAYA	Nibung-Karang Dapo-Rupit	16,2
K.012	BERINGIN MAKMUR II – TEBING TINGGI	Rawas Ilir	18,7
K.013	SUNGAI JAUH – SUNGAI KIJANG – POROS NIBUNG	Rawas Ulu	9,3
K.014	AIR BENING – PAUH	Rawas Ilir	16,6
K.015	JLN. KELURAHAN KARANG JAYA	Karang Jaya	2,1
K.016	SIMPANG BELANI – BELANI	Rawas Ilir	8,9
K.017	SIMPANG LAKE – BATAS MUSI RAWAS	Karang Jaya	18,5
K.018	SPG. KABU – DANAU RAYA	Rupit	8,4
K.019	MANDI ANGIN – BINA KARYA	Rawas Ilir-Karang Dapo	9,8
K.020	SIMPANG JADI MULYA – JADI MULYA	Nibung	5,6
K.021	SPG. LUBUK KUMBUNG – LUBUK KUMBUNG	Karang Jaya	5,9
K.022	PAUH I – BATU KUCING	Rawas Ilir	6,5
K.023	SETIA MARGA – BINA KARYA	Karang Dapo	5,45
K.024	JANGKAT – MUARA KULAM	Ulu Rawas	25,4
K.025	SIMPANG BIARO – BINGIN TELUK – BERINGIN MAKMUR II	Karang Dapo-Rawas Ilir	23,9
K.026	PANGKALAN – TRANS PANGKALAN	Rawas Ulu	6,4
K.027	SOSOKAN – KUTO TANJUNG	Ulu Rawas	12

K.028	SIMPANG LAKE – SUKAMENANG	Karang Jaya	8,5
K.029	SIMPANG LINTAS – BUKIT LANGKAP – BUKIT ULU	Karang Jaya	13,75
K.030	SIMPANG TERUSAN – TERUSAN	Karang Jaya	2,45
K.031	LESUNG BATU MUDA – BENDUNG MERUNG	Rawas Ulu	1,9
K.032	KERANI JAYA – SUMBER MAKMUR	Nibung	11,25
K.033	POROS NIBUNG – MULYA JAYA	Nibung	4,6
K.034	POROS NIBUNG – KELUMPANG JAYA	Nibung	7,8
K.035	SUNGAI LANANG – BATAS NIBUNG	Rawas Ulu	6,7
K.036	JADI MULYA I – TEBING TINGGI	Nibung	26,65
K.037	TEBING TINGGI – SUNGAI GULO – BATAS MUBA	Nibung-Rawas Ilir	19,65
K.038	SIMPANG RANTAU TELANG - KMPI – SUNGAI JAMBU	Karang Jaya	9,29
K.039	SUKARAJA – RANTAU JAYA	Karang Jaya	8,1
K.040	TEBING TINGGI – BUMI MAKMUR – SUMBER SARI	Nibung	4
K.041	BUKIT ULU – BUKIT LAYANG	Karang Jaya	2,03

The following is a picture of the research flow on Rigid Pavement Planning on the Lake Junction Road Section - Musi Rawas Boundary.

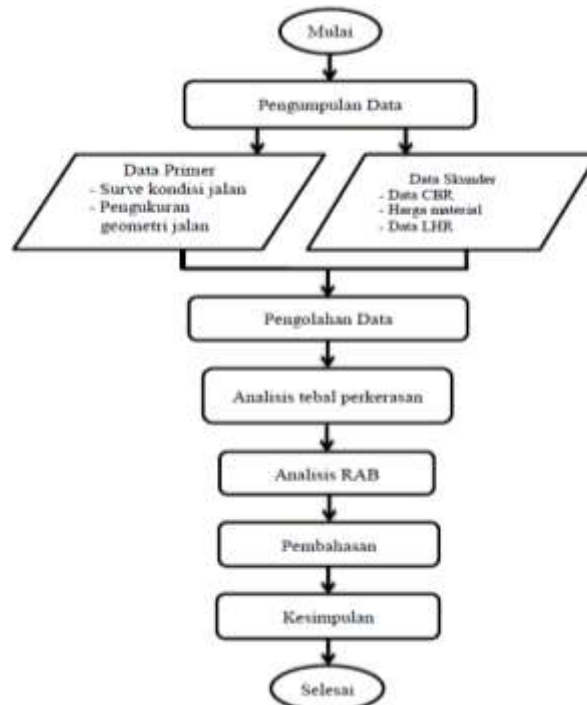


Figure 1. Research Flow Diagram

Traffic growth factors are based on growth data series or historical growth data with applicable growth factors. Can be seen with Table 2.

Table 2. Traffic Growth Factor (i) (%)

Traffic Growth Factor	Sumatera	Java	Kalimantan	Average Indonesia
Arterial and urban	4,83	4,80	5,14	4,75
Collector	3,50	3,50	3,50	3,50
Village Road	1,00	1,00	1,00	1,00

Calculation of the formula for the Number of Commercial Vehicle Axis Groups (JSKN) in the 2024 Pavement Design Manual as follows:

$$JSKN = \sum LHRJK \times JSKNJK \times 365 \times DL \times DD \times R$$

With:

JSKN = Total number of commercial vehicle axes over the life of the plan

LHRJK = Average daily traffic of each type of vehicle

JSKNJK = Load equivalent factor for each type of vehicle

DL = Lane distribution factor

DD = Directional distribution factor

R = Cumulative traffic growth multiplier

RESULTS AND DISCUSSION

This research resulted in a rigid pavement structure design on the Simpang Lake – Batas Musi Rawas section which was adjusted to traffic characteristics and soil conditions at the location. Based on Average Daily Traffic (LHR) data, the number of commercial vehicles crossing this section is 10 vehicles per day, consisting of light to medium vehicles, without the presence of heavy vehicles such as three-axle trucks. The dominant vehicle is a small two-axle truck (MST 5 tons), with the number of commercial vehicle axle groups (JSKN) during the planned life of 64,295.49. This figure is far below the threshold of 1 million ESA units set by the 2024 Pavement Design Manual (MDP, 2024), so this road section is categorized as a low-traffic road. Based on this, the designed road structure refers to Design Section-8A of the 2024 MDP which specifically handles roads with commercial vehicle LHRs < 50 vehicles/day.

Table 3. Daily Average Traffic Data of Commercial Vehicles

Group	Vehicle Type	Axle Configuration	Axle Group	Number of Vehicles per Day
Group 1	Motorcycles and three-wheeled vehicles	1,1	2	301
Group 2	Light vehicles (sedans, jeeps, station wagons)	1,1	2	181
Group 3	Medium-sized public transport vehicles	1,1	2	2
Group 4	Pick-up trucks, micro trucks	1,1	2	17
Group 5a	Small buses	1,1	2	0

Group	Vehicle Type	Axle Configuration	Axle Group	Number of Vehicles per Day
Group 5b	Large buses	1,2	2	0
Group 6a	Two-axle trucks – light	1,1	2	7
Group 6b	Two-axle trucks – medium	1,2	2	3
Group 7A1	Three-axle trucks – heavy	11,2	2	0
Group 7A2	Three-axle trucks – heavy	1,22	2	0
Group 7A3	Four-axle trucks – heavy	11,22	2	0
Group 7B1	Four-axle trucks – heavy	1.2+2.2	4	0
Group 7B2	Five-axle trucks – heavy	11.2+2.2	4	0
Group 7B3	Five-axle trucks – heavy	1.22+2.2	4	0
Group 7C1	Four-axle trucks – heavy	1.2-22	3	0
Group 7C2A	Five-axle trucks – heavy	1.22-22	3	0
Group 7C2B	Five-axle trucks – heavy	1.2-222	3	0
Group 7C3	Six-axle trucks – heavy	1.22-222	3	0
Group 7C4	Seven-axle trucks – heavy	1.22-2222	3	0

In this planning analysis, it is known that the value of the California Bearing Ratio (CBR) of the subsoil on the road section is 7.85%. This value shows that the subsoil has medium to high bearing strength, which allows the application of an aggregate foundation layer with a thickness of 150 mm according to the provisions in SNI Pd T-14-2003 (National Standardization Agency, 2003). Based on these parameters, the thickness of the concrete slab used is 150 mm with K-350 concrete quality, 100 mm thin concrete with K-125 concrete quality as the base layer, and class A aggregate foundation layer 150 mm thick. These three layers function synergistically in distributing the load of vehicles to the ground and increasing the rigidity of the road structure (Caddha et al., 2017).

Technical calculations are carried out based on traffic and geometric parameters listed in the 2024 MDP. The lane distribution factor (DL) of 100% is used because the road consists of one two-way lane. Meanwhile, a directional distribution factor (DD) of 0.5 is adopted to reflect a balanced proportion of traffic between directions. This calculation results in the

cumulative load value that is the basis for the planning of the pavement structure. In addition, the life of the road plan is determined for 20 years, as determined by the Directorate General of Highways, and adjusted to the latest MDP document (Road Pavement Design Manual, 2024). With this approach, the resulting design is expected to be able to survive in the long term without requiring major rehabilitation during the road service period.

Based on visual field observations and documentation, it is known that the existing condition of the road is still in the form of a dirt road with uneven surface conditions and is prone to inundation. Therefore, rigid pavement is the right alternative to apply. Rigid pavement offers resistance to plastic deformation, has high rigidity, and has a longer service life than flexible pavement (Pramudita, 2016). In addition, this structure is also able to withstand a high concentration of vehicle loads without experiencing a significant decrease in surface quality. This is important considering that the road is the main access to the plantation area and the distribution of agricultural products to the surrounding community. With a sturdy pavement design, people's mobility and productivity can be guaranteed in a sustainable manner.

To ensure structural integrity, the design also includes the installation of tie bars on transverse joints with a diameter of 13 mm, a length of 600 mm, and a spacing of 750 mm in accordance with the provisions of the MDP 2024. This tie bar is needed to prevent shifts between concrete plates due to vehicle loads and temperature changes. The transverse connection distance is determined along 4 meters, which is the optimal configuration for local roads with low traffic. The use of these joints and fasteners has been proven to be able to extend the service life of concrete slabs and prevent premature cracking (Caddha et al., 2017). This shows that not only the thickness of the layer, but also technical details such as joints play an important role in the overall performance of the pavement structure.

Tabel 4. Dimensions and Material Details of Road Pavement Structure

Component	Thickness (mm)	Material	Function
Concrete Slab	150	Concrete K-350	Primary load-bearing layer
Lean Concrete	100	Concrete K-125	Leveling and subbase support layer
Aggregate Base Layer	150	Class A Aggregate	Distributes load to subgrade

Analytical results show that the proposed structural design can withstand traffic loads for the 20-year plan life without the need for additional reinforcement. A 150 mm thick concrete slab of concrete grade K-350 serves as the main layer to withstand vehicle loads, while a 100 mm thick K-125 skinny concrete acts as a working base that improves flatness and stability. A 150 mm thick class A aggregate foundation layer was used to evenly distribute the load to the subgrade.

This study also adopted the standard connection and tie bar as per MDP 2024 with a transverse connection distance of 4.00 m and the use of 13 mm diameter steel tie bar. This aims to control cracking due to concrete shrinkage and provide integration between the concrete slabs. With this configuration, the resistance to cyclic loading can be improved. This

result is supported by the findings of Caddha et al. (2017), who stated that concrete slabs with proper connections will minimize deformation and extend the service life of the road.

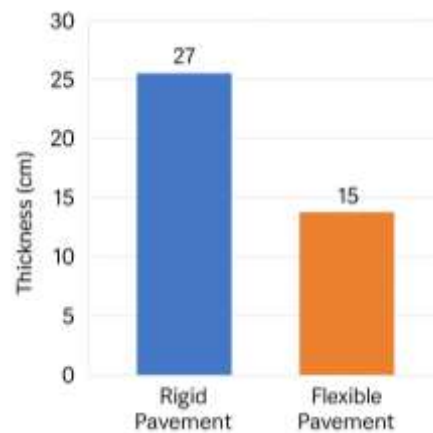


Figure 2. Comparison of Rigid Pavement Design & Flexible Pavement Design

This research is in line with the results of a study conducted by Farid (2013) which showed that the selection of rigid pavement for roads with light traffic is able to reduce annual maintenance costs by up to 30% compared to flexible pavement. Furthermore, the selection of the appropriate type of concrete and thickness is able to provide optimal structural and economic efficiency. Pramudita (2016) also shows that the application of design based on actual traffic conditions is much more effective than a general approach that does not consider specific traffic data. Therefore, an actual data-based approach such as this study has the advantage of producing road designs that meet local needs and budgets.

The overall results and discussion show that the pavement structure designed is in accordance with the technical characteristics of the road section and national standards. The structure consists of concrete slabs, thin concrete, aggregate layers, as well as joint details designed for low traffic, providing protection against deformation, cracking, and premature damage. These design recommendations can be used as a guideline for local governments in the construction and maintenance of similar roads, as well as as a basis for evidence-based technical decision-making and long-term cost efficiency.

CONCLUSION

The results of calculations carried out in research with rigid pavement planning on the Lake Simpang - Musi Rawas Boundary Road Section project (STA 1 + 700 - 6 + 500) with a length of 18.5 km obtained a concrete plate thickness of 150 mm, a thin concrete thickness of 100 mm, an aggregate foundation layer with a thickness of 150 mm and has a Tie Bar with a 4 m transverse connection distance. The data used in calculating rigid pavement must be complete to facilitate the calculation of pavement planning. For the calculation of the cost budget plan is based on the standards agreed upon by the region/area of work.

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