Analysis of the MDPJ 2024 Method in Planning Flexible Pavement Thickness on the Rancabali – Bandung Cianjur Border Road

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Abstract

This study analyzes the application of the 2024 Manual for Road Pavement Design (MDPJ) Method in planning the flexible pavement thickness on the Rancabali – Bandung Cianjur Border Road segment. The analysis is based on existing data for the 14.81km arterial road section, with a design life of 20 years. The design requirements take into account daily traffic, vehicle growth, load distribution, and subgrade bearing capacity, following the MDPJ 2024 guidelines. Traffic projection up to the construction year and the use of the regional Vehicle Damage Factor (VDF) according to standards are applied to calculate the cumulative standard axle load (CESAL). Based on the calculations, the recommended pavement structure consists of an AC-WC layer of 40mm, AC-BC layers of 65mm and 80mm, an LFA Class A layer of 200mm, and an LFA Class B layer of 150mm, with a total thickness reaching 53.5cm, adjusted for optimal capacity and service life. These results are consistent with recent studies of other road cases in Indonesia using similar methods, which demonstrate the advantages of MDPJ 2024 in delivering efficient, accurate, and applicable designs under various field and traffic load conditions. The application of this method is expected to minimize the risk of premature damage and support better mobility for the community and goods distribution in the study area.

Keywords: MDPJ 2024, flexible pavement thickness, CESAL, arterial road, Rancabali – Bandung Cianjur Border, road design, Vehicle Damage Factor (VDF), traffic growth..

1. INTRODUCTION

Road infrastructure development is a fundamental foundation in supporting the mobility and economic growth of a region (Directorate General of Highways, 2024). Specifically, on the Rancabali – Bandung Cianjur Border road segment, which functions as an arterial road, proper pavement design is critically important to support socio-economic activities in the area (Ministry of Public Works and Public Housing, 2012). The main challenges in pavement planning include variations in subgrade soil conditions, continuously increasing traffic projections, and budget constraints for implementation and maintenance (Alifvian et al., 2025).

In this context, flexible pavements are widely applied due to their adaptability in accommodating soil movement and deformation as well as relatively efficient construction costs (Irsan, 2023). The structure of flexible pavements consists of multiple layers designed to distribute vehicle loads evenly and prevent rapid deterioration of the subgrade layer (Andriono, 2021). Therefore, accurate calculation of thickness is crucial to maintaining the optimal service life of the road (Directorate General of Highways, 2024).

The 2024 Manual for Road Pavement Design (MDPJ 2024) is the latest guideline integrating mechanistic-empirical approaches and local material characteristics in pavement planning (Directorate General of Highways, 2024). This method replaces the previous edition by updating design parameters and adapting them to actual traffic conditions in Indonesia, including adjustments for growth factors and vehicle load distributions (Alifvian et al., 2025). Various studies have shown that MDPJ 2024 produces more efficient designs compared to older methods, making it highly relevant for application on main roads such as the Rancabali – Bandung Cianjur Border segment (Department of Public Works, 1987; Andriono, 2021).

Classification of Roads Based on Road Status in Indonesia is as follows:

1. National Roads

   National roads are collector roads within the primary road network system that connect provincial capitals, national strategic roads, and toll roads.

2. Provincial Roads

   Provincial roads are collector roads within the primary road network system that connect provincial capitals with regency/city capitals, or connect between regency/city capitals, as well as provincial strategic roads.

3. Regency Roads

   Regency roads are local roads within the primary road network system that connect regency capitals with district capitals, between district capitals, or regency capitals to local activity centers. This also includes public roads within the secondary road network system in the regency area, and regency strategic roads.

4. City Roads

   City roads are public roads within the secondary road network system that connect between service centers within the city, between service centers and land parcels, between land parcels, as well as between residential centers within the city.

5. Village Roads

   Village roads are public roads connecting areas and/or settlements within villages as well as neighborhood roads.

2. RESEARCH METHODOLOGY

In this study, the method for planning flexible pavement thickness is based on the 2024 edition of the Manual for Road Pavement Design (MDPJ) issued by the Directorate General of Highways. The planning process considers several key aspects, including the design service life of the road, the traffic volume growth rate, the average daily traffic volume, vehicle load distribution on the analyzed lane, Vehicle Damage Factor (VDF), subgrade strength measured by the California Bearing Ratio (CBR), cumulative equivalent standard axle load (CESAL), selection of pavement structure type, and determination of thickness for each pavement layer to be applied.

The initial stage of planning begins with determining a design life of 20 years for the new road. The traffic volume value at the base year (ADT_0) is obtained from available secondary data without conducting field traffic surveys. This data is then used to estimate the traffic volume at the implementation year or at the end of the design life using the following traffic growth formula:

$$LHR_A = LHR_0 \times (1 + i)^n \quad (1)$$

Where **i** is the annual traffic growth rate and **n** is the design life in years.

In the calculation of the total traffic load over the design life, the parameter called **CESAL** (Cumulative Equivalent Standard Axle Load) is used. This value is obtained by multiplying the average daily traffic volume of commercial vehicles (**LHRJK**), the Vehicle Damage Factor (**VDFJK**), the directional distribution factor (**DD**), the lane distribution factor (**DL**), and the cumulative growth factor (**R**).

The cumulative growth factor **R** is determined by the equation:

$$R = \frac{(1+0{,}01\,i)^{UR}-1}{0{,}01} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The overall CESAL calculation formula is as follows:

$$CESAL = (\sum LHR_{JK} \times VDF_{JK})\times 365 \times DD \times DL \times R \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

the average daily traffic volume by type of commercial vehicle (LHRJK) is used as one of the parameters in traffic load calculation, where VDFJK is the load equivalency factor for each vehicle type, referenced from the MDPJ 2024 table. The directional distribution factor (DD) is usually assumed to be 0.5 for roads with two-way traffic, while the lane distribution factor (DL) is determined based on the number of lanes per direction according to the table provided in MDPJ 2024.

To facilitate the completion of the study, below is a flowchart of the research steps.

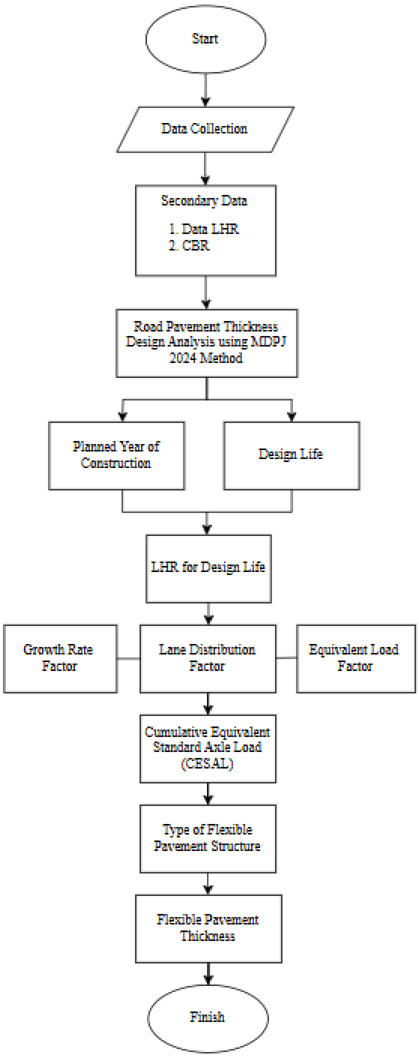


Figure 1 Flow Chart
Source: (Analysis Results, 2025)

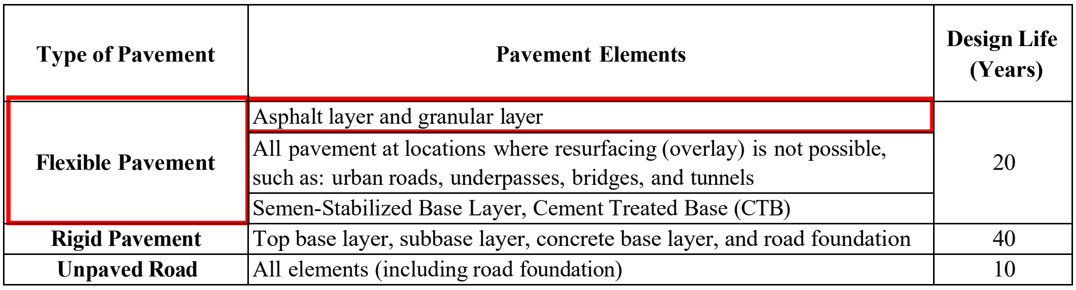
3. DISCUSSION

3.1 Road Data

Road Name : Rancabali – Bandung and Cianjur Border
Road Function : Arterial Road
Road Length : 14.81 km
Pavement Type: Flexible Pavement
Road Type : 4 Lanes, 2 Directions

3.2 Design Life

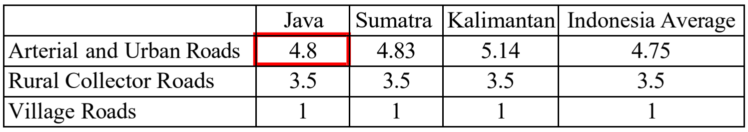
The selection of a 20-year design life for the flexible pavement on the Rancabali – Bandung and Cianjur Border Road was made by considering the standard provisions stated in MDPJ 2024 and the existing road conditions, some of which have been partially constructed previously.



Type of Pavement	Pavement Elements	Design Life (Years)
Flexible Pavement	Asphalt layer and granular layer	20
	All pavement at locations where resurfacing (overlay) is not possible, such as: urban roads, underpasses, bridges, and tunnels	
	Semen-Stabilized Base Layer, Cement Treated Base (CTB)	
Rigid Pavement	Top base layer, subbase layer, concrete base layer, and road foundation	40
Unpaved Road	All elements (including road foundation)	10

Figure 2 Design Life
Source : (MDPJ, 2025)

3.3 Traffic Growth Rate Factor

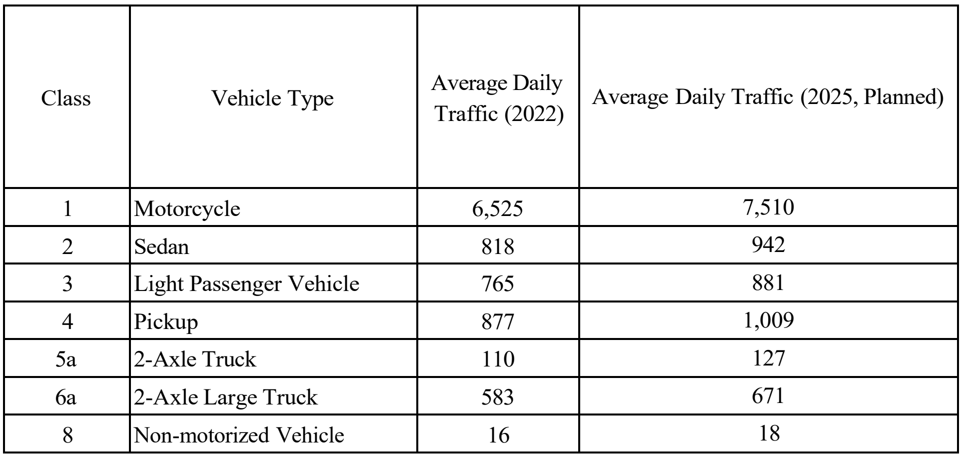


	Java	Sumatra	Kalimantan	Indonesia Average
Arterial and Urban Roads	4.8	4.83	5.14	4.75
Rural Collector Roads	3.5	3.5	3.5	3.5
Village Roads	1	1	1	1

Figure 3 Traffic Growth Rate Factor
Source : (MDPJ, 2025)

Sesuai dengan lokasi jalan dan fungsi jalan, maka nilai faktor pertumbuhan lalu lintas dalam perencanaan adalah 4,8 ini mengacu pada ketentuan standar yang tercantum dalam MDPJ 2024.

3.4 LHR



Class	Vehicle Type	Average Daily Traffic (2022)	Average Daily Traffic (2025, Planned)
1	Motorcycle	6,525	7,510
2	Sedan	818	942
3	Light Passenger Vehicle	765	881
4	Pickup	877	1,009
5a	2-Axle Truck	110	127
6a	2-Axle Large Truck	583	671
8	Non-motorized Vehicle	16	18

Figure 4 LHR
Source : (MDPJ, 2025)

3.5 Lane Distribution Factor (DL) and Directional Distribution Factor (DD)

Number of Lanes Each Direction	Commercial Vehicles in Design Lane (% of Commercial Vehicle Population)
1	100
2	80
3	60
4	50

Figure 5 DL
Sumber : (MDPJ, 2025)

The directional distribution factor (DD) is adjusted to the two-way traffic system on this road segment, therefore the DD value used follows the recommendation in MDPJ 2024, which is 0.5.

3.6 Vehicle Damage Factor (VDF)

Vehicle Type	**Jawa Barat - Lintas Selatan**			
	(VDF 4)	**(VDF 4)**	**(VDF 5)**	**(VDF 5)**
	Actual	**Normal**	**Actual**	**Normal**
5B	1,2	1,2	1,3	1,3
6A	0,5	0,5	0,4	0,4
6B	1,4	0,3	1,8	0,2
7A1	-	-	-	-
7A2	9,8	3,4	19,3	4,4
7A3	-	-	-	-
7B1	-	-	-	-
7B2	-	-	-	-
7B3	-	-	-	-
7C1	3,8	2,3	5,3	2,7
7C2A				
7C2B	12	6,1	20,4	8,5
7C3	26,3	10,3	54,8	15,1
7C4				

Figure 6 VDF
Source : (MDPJ, 2025)

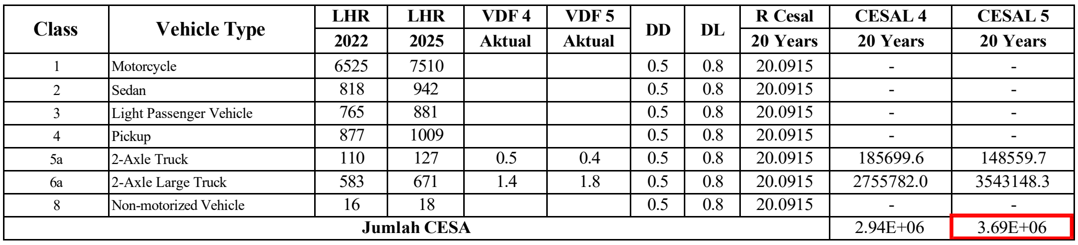
Due to the absence of control measures, initial actions, and uncertainties regarding the use of vehicle loads on the Rancabali – Bandung and Cianjur Border road segment, the axle load conditions on this road are considered to be unstable or not yet normal. Therefore, in accordance with the provisions stipulated in MDPJ 2024, the design for this section uses factual Vehicle Damage Factor (VDF) values established based on vehicle categories derived from the Average Daily Traffic (LHR) data.

3.7 Subgrade Bearing Capacity

Since the MDPJ 2024 sets the foundation design parameters based on traffic conditions with a design life of 40 years, whereas this study uses a design life of only 20 years, the required pavement structure and cumulative load are consequently lighter. This difference in design life duration makes the foundation design approach outlined in MDPJ 2024 less relevant for application in this study. Therefore, a specific subgrade foundation design was not performed, and the pavement structure analysis proceeded using an alternative approach better suited to the actual traffic conditions and planned design life.

By not applying a detailed subgrade foundation design, the subsequent focus is on pavement structure planning based on traffic loads converted into the unit of Cumulative Equivalent Standard Axle Load (CESAL). The CESAL calculation aims to determine the total standard axle loads that the pavement will be subjected to over the road's service life.

3.8 Cumulative Equivalent Standard Axle Load (CESAL)

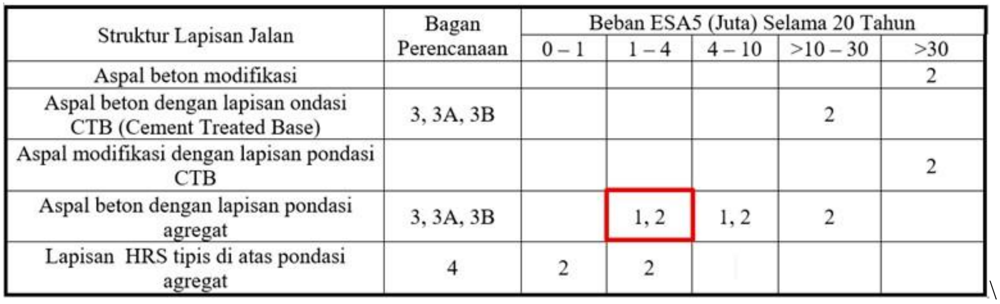


Class	Vehicle Type	LHR	LHR	VDF 4	VDF 5	DD	DL	R Cesal	CESAL 4	CESAL 5
		2022	2025	Aktual	Aktual			20 Years	20 Years	20 Years
1	Motorcycle	6525	7510			0.5	0.8	20.0915	-	-
2	Sedan	818	942			0.5	0.8	20.0915	-	-
3	Light Passenger Vehicle	765	881			0.5	0.8	20.0915	-	-
4	Pickup	877	1009			0.5	0.8	20.0915	-	-
5a	2-Axle Truck	110	127	0.5	0.4	0.5	0.8	20.0915	185699.6	148559.7
6a	2-Axle Large Truck	583	671	1.4	1.8	0.5	0.8	20.0915	2755782.0	3543148.3
8	Non-motorized Vehicle	16	18			0.5	0.8	20.0915	-	-
Jumlah CESA									2.94E+06	3.69E+06

Figure 7 CESAL
Source : (MDPJ, 2025)

Since the design uses flexible pavement, according to MDPJ 2024, the pavement thickness calculation is based on the cumulative traffic load expressed in Equivalent Standard Axle (ESA) to the power of five, denoted as CESAL5. Based on the calculations presented in the table, the total CESAL5 value amounts to 3,69 x 10^6.

3.9 Type of Flexible Pavement Structure



Struktur Lapisan Jalan	Bagan Perencanaan	Beban ESA5 (Juta) Selama 20 Tahun				
		0 – 1	1 – 4	4 – 10	>10 – 30	>30
Aspal beton modifikasi						2
Aspal beton dengan lapisan ondasi CTB (Cement Treated Base)	3, 3A, 3B				2	
Aspal modifikasi dengan lapisan pondasi CTB						2
Aspal beton dengan lapisan pondasi agregat	3, 3A, 3B		1, 2	1, 2	2	
Lapisan HRS tipis di atas pondasi agregat	4	2	2			

Figure 8 Type of Flexible Pavement Structure
Source : (MDPJ, 2025)

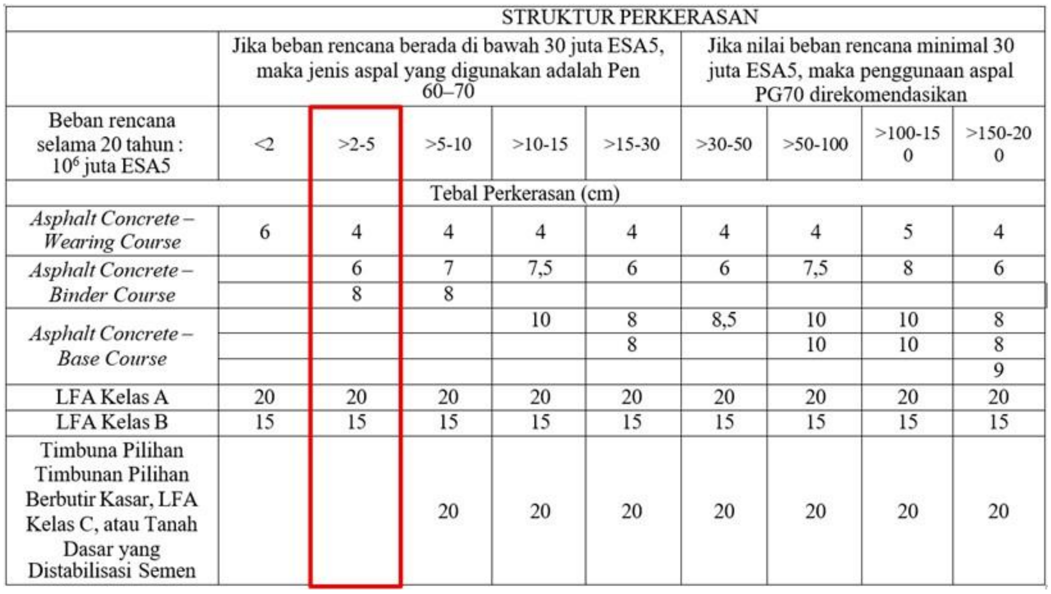
Based on the table above, note numbers 1 and 2 in MDPJ 2024 refer to the scale of construction contractors. Note 1 pertains to implementation by small- to medium-scale contractors, while note 2 refers to large contractors with greater resource capacity. This classification provides flexibility in project execution, as projects can be undertaken by contractors of various scales, depending on the availability and readiness of implementers in the local area.

Furthermore, the table also presents the results for the selected flexible pavement thickness design diagrams to be used, namely diagrams 3, 3A, and 3B. In MDPJ 2024:

- Design Diagram 3 refers to flexible pavement with a Cement Treated Base (CTB) layer.
- Design Diagram 3A refers to flexible asphalt pavement using an aggregate base layer.
- Design Diagram 3B is an adjustment for structures with a selected granular fill layer composed of coarse-grained material, which is specifically applied when using Design Diagram 3A and the 20-year design load exceeds 5 million ESA.

According to MDPJ 2024, flexible pavement with a CTB base layer tends to be more economical if the planned loading exceeds 10 million ESA5. However, based on the calculations, the CESAL value is 3.69 million ESA5, indicating that it has not exceeded the threshold. Thus, for the flexible pavement structure design on this road segment, a CTB base layer is not used. Instead, considering the availability of local contractors and implementation efficiency, the use of an aggregate base layer is deemed more appropriate.

3.10 Flexible Pavement Thickness



STRUKTUR PERKERASAN									
	Jika beban rencana berada di bawah 30 juta ESA5, maka jenis aspal yang digunakan adalah Pen 60–70					Jika nilai beban rencana minimal 30 juta ESA5, maka penggunaan aspal PG70 direkomendasikan			
Beban rencana selama 20 tahun : 10^6 juta ESA5	<2	>2-5	>5-10	>10-15	>15-30	>30-50	>50-100	>100-150	>150-200
Tebal Perkerasan (cm)									
Asphalt Concrete – Wearing Course	6	4	4	4	4	4	4	5	4
Asphalt Concrete – Binder Course		6	7	7,5	6	6	7,5	8	6
		8	8						
Asphalt Concrete – Base Course				10	8	8,5	10	10	8
					8		10	10	8
									9
LFA Kelas A	20	20	20	20	20	20	20	20	20
LFA Kelas B	15	15	15	15	15	15	15	15	15
Timbuna Pilihan Timbunan Pilihan Berbutir Kasar, LFA Kelas C, atau Tanah Dasar yang Distabilisasi Semen			20	20	20	20	20	20	20

Figure 9 Flexible Pavement Thickness
Source : (MDPJ, 2025)

Referring to the analysis results presented in the table above, the ESA5 value falls within the range of 2 to 5 million. Therefore, the designed flexible pavement structure consists of an AC-WC layer with a thickness of 40 mm, AC-BC layers of 65 mm and 80 mm, Class A LFA layer with a thickness of 200 mm, and Class B LFA layer with a thickness of 150 mm. This design outcome is the result of cumulative traffic load calculations, which are then integrated with the initial road planning data.

3.11 Flexible Pavement Thickness Design

To clarify, the following is an illustration of the planned road cross-section that depicts the composition of the pavement layers according to the analysis results.

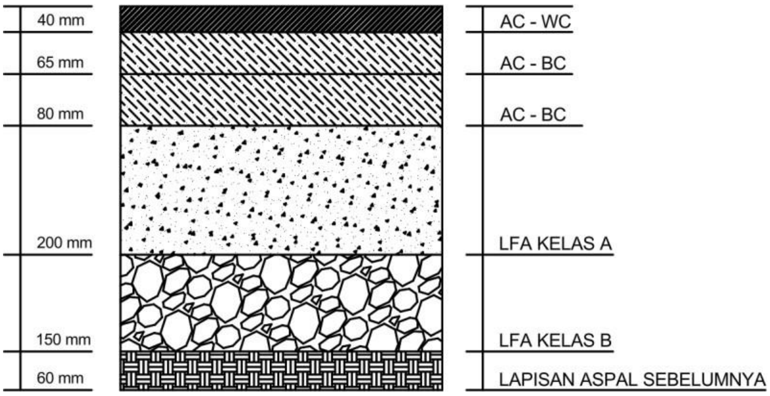


Figure 10 Flexible Pavement Thickness Design
Source : (MDPJ, 2025)

4. CONCLUSION

This study was conducted in response to the existing condition of the Rancabali – Bandung and Cianjur Border Road, which has suffered significant physical damage and lacks an adequate pavement structure. Based on traffic analysis and technical data obtained from the MDPJ 2024 approach, the annual traffic growth rate is 4.8%, and the cumulative traffic load (CESA5) reaches 3.69 × 10^6 ESA. The planning adopts a design life of 20 years as the basis for calculating the appropriate flexible pavement thickness to meet the functional requirements of the road.

The pavement structure design resulting from the MDPJ 2024 method is a flexible asphalt pavement with an aggregate base layer, without the use of a Cement Treated Base (CTB) layer, referring to Design Diagram 3A. This choice is based on the design load being below the threshold for CTB application, as well as the limitations of local contractor resources. Therefore, this design is not only technically appropriate but also realistic for implementation given the regional conditions.

The total planned pavement thickness is 53.5 cm, consisting of a 4 cm AC-WC layer, 6.5 cm and 8 cm AC-BC layers, a 20 cm Class A LFA layer, and a 15 cm Class B LFA layer. This structure is designed to enhance the road's strength and service life while reducing the risk of premature damage that could hinder community mobility and the distribution of essential goods.

The application of the MDPJ 2024 method in planning the pavement thickness for the Rancabali – Bandung and Cianjur Border Road demonstrates that the use of the latest standards not only improves the technical reliability of the pavement structure but also supports project efficiency and infrastructure sustainability. By tailoring the design based on actual traffic data and subgrade soil conditions, the planning results are more relevant to field requirements. This has the potential to enhance interregional connectivity.

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