Analysis of Rigid Pavement Thickness Using the AASHTO 1993 and MDPJ 2024 Methods

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ABSTRACT

Rigid pavement is an important feature of highway infrastructure because it can handle heavy traffic and move it quickly to the subgrade. This study on Section IIB of the Jakarta–Cikampek II South Toll Road Project used two different ways to construct rigid pavement: one that is used all over the world and one that is exclusive to Indonesia. Each approach utilises a different way of analysing that is based on the criteria and conditions of the context in which it is used. The results showed that the first method made a pavement thickness of 28 cm, whereas the second method made a thickness of 29,5 cm. This difference has a big effect on the total cost of building the 13 km toll road segment, which is Rp139.390.857.060,00 for the first method and Rp156.801.134.100,00 for the second. Choosing the ideal design strategy for a pavement solution that is both optimal and long-lasting should take into account local factors, project needs, and cost-effectiveness.

Keywords: AASHTO 1993, MDPJ 2024, pavement structure cost, rigid pavement.

INTRODUCTION

The growth in the number of vehicles and increased mobility of the population due to economic development has led to high traffic volumes, especially on strategic routes such as the Jakarta – Cikampek Toll Road. As a measure to address this, the government is constructing the Jakarta – Cikampek II South Toll Road, which aims to reduce congestion and accelerate connectivity between regions. In section IIB, rigid pavement is used due to its resistance to heavy loads and high traffic volumes. However, pavement thickness calculations must be performed accurately to avoid premature damage or budget wastage, necessitating a design method suited to local traffic conditions and soil characteristics [1], [2].

Various studies have been conducted to compare pavement design methods such as AASHTO 1993 and MDPJ 2017/2024. Studies by [3], [4], and [5] show differences in concrete slab thickness calculations based on the methods used, [6] and [7] also highlight the cost implications of the chosen design method. Some studies also discuss cost efficiency between national and international methods. However, there are few studies that directly compare the AASHTO 1993 and MDPJ 2024 methods in real-world projects such as the Jakarta - Cikampek II South Section IIB Toll Road, particularly in the context of thickness calculations and cost efficiency using AHSP adjusted for current inflation.

This study aims to analyze and compare the thickness of rigid pavement using the AASHTO 1993 and MDPJ 2024 methods, as well as calculate the Unit Price of Work (UPW) from the planning results by adjusting the AHSP data to 2025 prices. This study is expected to contribute to the design of rigid pavements that are not only structurally strong but also economically efficient. The novelty of this study lies in the application of actual cost analysis based on the latest method (MDPJ 2024). and international comparison (AASHTO 1993) in an actual toll road project, which has not been extensively discussed in previous studies.

RESEARCH METHODS
Materials

This study was conducted on the Jakarta–Cikampek II South Toll Road Construction Project, specifically at Section IIB, spanning STA 17+750 to STA 30+750 with a total length of 13 km. The project site is located in Sukasari Village, Serang Baru District, Bekasi Regency, West Java Province. This location was chosen because it represents an active construction area implementing rigid pavement with a thickness of 30 cm, making it relevant for comparing pavement thickness design methods and their cost efficiency.

The primary data used are secondary data, obtained from various stakeholders without direct observation. These include the Detailed Engineering Design (DED), CBR values, concrete specifications, Average Daily Traffic data, construction price analysis, local inflation data (2024–2025), and supporting literature such as journals and technical manuals related to the AASHTO 1993 and MDPJ 2024 methods.

Methods

This research follows several key procedures. First, traffic data from 2020 is projected to the operational year (2026) using growth rate factors to ensure accurate design loads. Then, the pavement thickness is analyzed using both the AASHTO 1993 method and the MDPJ 2024 method.

The AASHTO 1993 method applies an empirical approach using Equivalent Single Axle Load (ESAL), reliability levels, serviceability loss, subgrade reaction modulus, and concrete properties. The design thickness is obtained through iterative calculations using a standard equation [8], [9].

In contrast, the MDPJ 2024 method uses a mechanistic-empirical approach, focusing on cumulative axle loads (JSKN), growth rates, foundation layers, and concrete flexural strength. This method includes fatigue and erosion analysis to ensure structural performance within the expected service life [10].

After determining the final pavement thicknesses, material quantities such as dowels and tie bars are calculated for a sample section measuring 5 m x 9,3 m [11], [12]. The unit price calculation is carried out using AHSP data from 2023, which is updated to 2025 values based on inflation rates [13]. The costs are then scaled up to represent the entire 13 km dual-carriageway project.

The complete sequence of research steps is summarized in Figure 1, which outlines the process from literature review, data collection, design analysis, and cost estimation, to final conclusions.
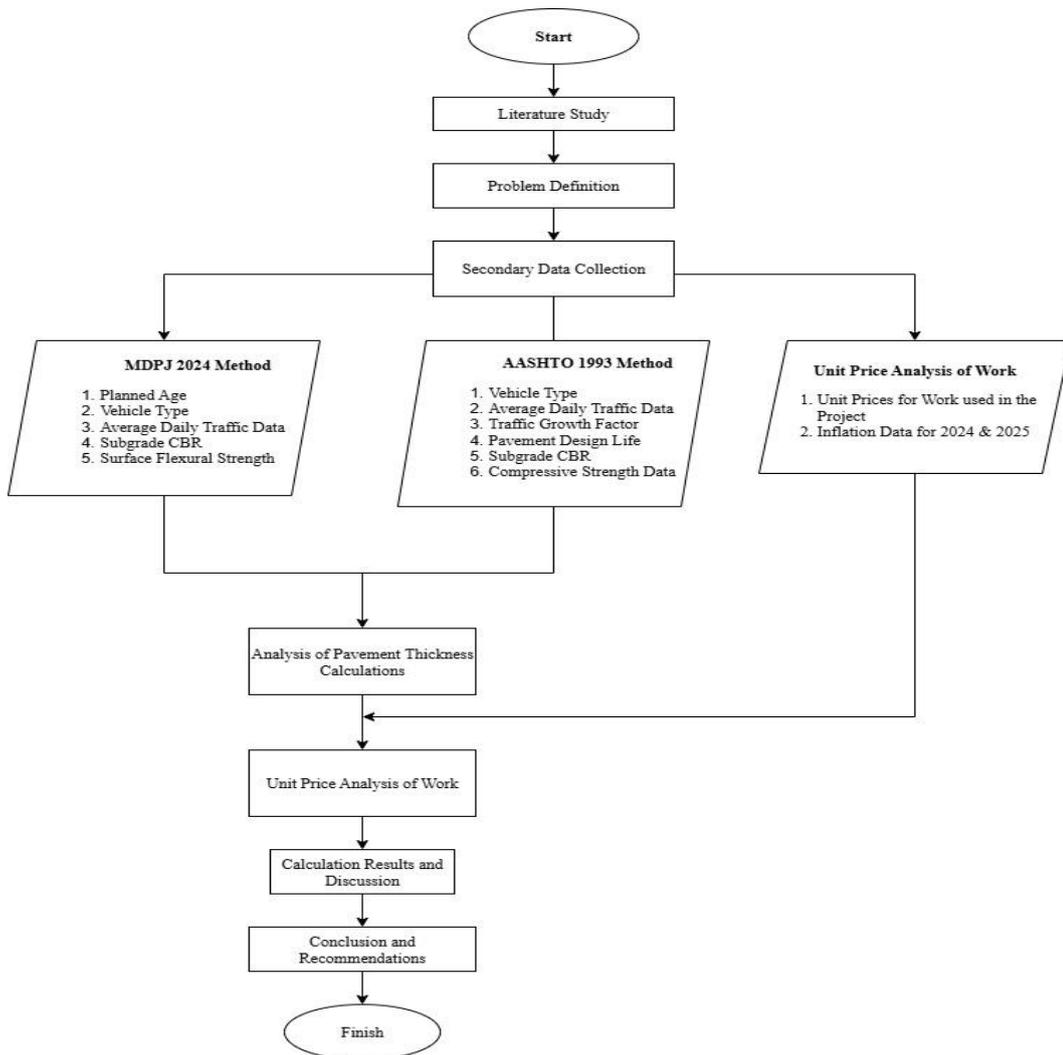
Figure 1. Flow chart

Data Analysis

The data were analyzed through comparative calculations of rigid pavement thickness using both AASHTO 1993 and MDPJ 2024 methods. ESAL values, JSKN projections, and supporting parameters such as CBR, modulus of elasticity, drainage coefficients, and load transfer factors were computed using standard formulas [14]. Furthermore, the final pavement thickness from both methods was subjected to a cost analysis based on updated AHSP data for 2025, enabling a comparative evaluation of economic feasibility. All findings are presented in tabular and graphical form to support the study's conclusions and assess the more efficient design approach.

RESULT AND DISCUSSION

In the 1993 AASHTO method, all types of vehicles are taken into account in traffic analysis through the Vehicle Damage Factor (VDF) value, without distinguishing between minimum vehicle weights, because each still contributes to pavement damage, albeit to a small extent [15]. Conversely, the MDPJ 2024 method only includes vehicles weighing over 5 tons in the calculations, as light vehicles are considered to have no significant impact on pavement structure.

The toll road for this project is designed with two lanes and two lanes, using 30 cm thick Jointed Plain Concrete Pavement (JPCP) for the road surface. The segment width for each lane is 4,3 meters

and 3,7 meters, while the inner shoulder and outer shoulder have widths of 1.3 meters and 2.4 meters, respectively. The inner shoulder uses rigid pavement, while the outer shoulder uses flexible pavement. Based on traffic data, the annual vehicle growth rate is projected at 4,88%, with a road design life of 20 years, resulting in a cumulative traffic growth factor (R) of 32,65. The following is the 2020 Average Daily Traffic (ADT) data from the project, converted to the operational year 2026 using the formula ADT 2020 x $(1+i)6$.

Table 1. Average daily traffic data for 2026

No.	Vehicle Classification	Vehicle Type	Axle Configuration	Axle Group	Number of Vehicles	Unit
1	2	Sedan	1.1	2	14.308	vehicles/day
2	2	Jeep	1.1	2	12.264	vehicles/day
3	4	Pick-up/Small Truck	1.1	2	8.176	vehicles/day
4	5A	Small Bus	1.1	2	3.679	vehicles/day
5	5B	Large Bus	1.2	2	2.453	vehicles/day
6	6A	Truck with 2 axles – Light Truck	1.1	2	2.984	vehicles/day
7	6B	Truck with 2 axles – Medium Truck	1.2	2	2.441	vehicles/day
8	7A1	Truck with 3 axles – Heavy	11.2	2	764	vehicles/day
9	7A2	Truck with 3 axles – Heavy	1.22	2	1.146	vehicles/day
10	7A3	Truck with 3 axles – Heavy	11.22	2	149	vehicles/day
11	7B1	Truck with 4 axles – Heavy	1.2+2.2	4	239	vehicles/day
12	7C1	Truck with 4 axles – Heavy	1.2-22	3	209	vehicles/day
13	7B2	Truck with 5 axles – Heavy	11.2+2.2	4	190	vehicles/day
14	7C2A	Truck with 5 axles – Heavy	1.22-22	3	233	vehicles/day
		TOTAL			49.175	vehicles/day

A. Based on the AASHTO 1993 Method

This method requires several parameters, starting with identifying the axle configuration and vehicle axle type as shown in the following table [6], [14].

Table 2. Vehicle load axis configuration

No.	Vehicle Type	Max Weight (Ton)	Axle and Wheel Type
1	Sedan, jeep, pick up/small truck	2	Single Axle Single Wheel
2	Small bus	6	Single Axle Single Wheel
3	Large bus	9	Single Axle Dual Wheel
4	Truck with 2 axles - light	12	Single Axle Single Wheel
5	Truck with 2 axles - medium	16	Single Axle Dual Wheel
6	Truck with 3 axles (11.2)	18	Tandem Axle Dual Wheel
7	Truck with 3 axles (1.22)	20	Tandem Axle Dual Wheel
8	Truck with 4 axles (11.22)	25	Tandem Axle Dual Wheel

No.	Vehicle Type	Max Weight (Ton)	Axle and Wheel Type
9	Truck with 4 axles (1.2+2.2)	30	Tandem Axle Dual Wheel
10	Truck with 4 axles (1.22-2)	35	Tandem Axle Dual Wheel
11	Truck with 5 axles (11.2+2.2)	40	Tandem Axle Dual Wheel
12	Truck with 5 axles (1.22-22)	42	Tandem Axle Dual Wheel

Table 3. Illustration of vehicle axle distribution

No.	Vehicle Type	Vehicle Axle Distribution
1.	Sedan, jeep, pick up/small truck	
2.	Small bus	
3.	Large bus	
4.	Truck with 2 axles - light	
5.	Truck with 2 axles - medium	
6.	Truck with 3 axles (11.2)	
7.	Truck with 3 axles (1.22)	
8.	Truck with 4 axles (11.22)	
9.	Truck with 4 axles (1.2+2.2)	
10.	Truck with 4 axles (1.22-2)	
11.	Truck with 5 axles (11.2+2.2)	
12.	Truck with 5 axles (1.22-22)	
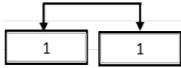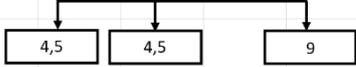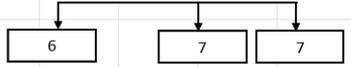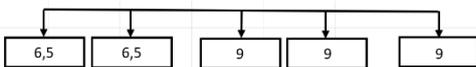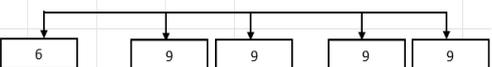
Next, the Vehicle Damage Factor (VDF) value for each type of vehicle is calculated using the following equation:

$$VDF = \left(\frac{Vehicle\ axle\ load}{Standard\ axle\ load} \right)^4 \qquad (1)$$

where:

- Axle Load of Vehicle is the maximum axle load of the vehicle concerned (in tons)

- Standard Axle Load is generally considered to be 8.16 tons in accordance with AASHTO regulations.

The VDF calculation results for each type of vehicle are presented in the following table.

Table 4. Vehicle VDF value

No.	Vehicle Type	VDF
1	Sedan, jeep, pick up/small truck	0,0005
2	Small bus	0,0613
3	Large bus	0,3106
4	Truck with 2 axles - light	0,6825
5	Truck with 2 axles - medium	3,4432
6	Truck with 3 axles (11.2)	1,6071
7	Truck with 3 axles (1.22)	1,0375
8	Truck with 4 axles (11.22)	1,0292
9	Truck with 4 axles (1.2+2.2)	3,4685
10	Truck with 4 axles (1.22-2)	4,7243
11	Truck with 5 axles (11.2+2.2)	4,9935
12	Truck with 5 axles (1.22-22)	4,3648

In calculating the ESAL value, a directional distribution factor (D_D) of 0,5 is used. Considering the number of two lanes in one lane, based on the lane distribution factor (D_L) table in the AASHTO 1993 guidelines, the value is 80%. The number of days in a year used in the calculation is 365 days. The ESAL value is then calculated using the formula:

$$W_{18} = \sum_{N1}^{Nn} LHR_j \times DF_j \times D_D \times D_L \times 365$$

(2)

Combining all these parameters yields the following result.

Table 5. ESAL value

No.	Vehicle Type	ADT	VDF	D_D	D_L	Days per Year	ESAL
1	Sedan, jeep, pick up/small truck	34.749	0,0005	0,5	0,8	365	2.288,56
2	Small bus	3.679	0,0613	0,5	0,8	365	32.955,23
3	Large bus	2.453	0,3106	0,5	0,8	365	111.223,91
4	Truck with 2 axles - light	2.984	0,6825	0,5	0,8	365	297.313,12
5	Truck with 2 axles - medium	2.441	3,4432	0,5	0,8	365	1.227.213,83
6	Truck with 3 axles (11.2)	764	1,6071	0,5	0,8	365	179.250,36
7	Truck with 3 axles (1.22)	1.146	1,0375	0,5	0,8	365	173.575,38
8	Truck with 4 axles (11.22)	149	1,0292	0,5	0,8	365	22.397,91
9	Truck with 4 axles (1.2+2.2)	239	3,4685	0,5	0,8	365	120.777,53
10	Truck with 4 axles (1.22-2)	209	4,7243	0,5	0,8	365	143.944,62
11	Truck with 5 axles (11.2+2.2)	190	4,9935	0,5	0,8	365	138.851,56
12	Truck with 5 axles (1.22-22)	233	4,3648	0,5	0,8	365	148.340,96
	TOTAL						**2.598.132,98**

Next, the cumulative ESAL value (W_{18}) is calculated by multiplying the total annual ESAL value by the traffic growth factor (R), resulting in a value of 84.828.235,48.

Following this, the design parameters for calculating pavement thickness are determined using the AASHTO 1993 method. For rural highway planning, a reliability value of 90% is set based on the recommended range in the specification table, resulting in a standard normal deviation (Z_R) of – 1,282 and a standard deviation (S_o) of 0,35. The initial serviceability index (P_o) used was 4,5, and the terminal serviceability index (P_t) was 2,5, resulting in a serviceability reduction (ΔPsi) of 2. The drainage coefficient (Cd) is set at 1,25 based on very good drainage conditions with the structure exposed to rainwater <1% per year, while the load transfer coefficient (J) value of 2,8 is obtained from the dowel joint. The CBR value of the subgrade soil is 6%, resulting in a resilient modulus (M_R) of 9000 psi and a subgrade reaction modulus (k) of 463,92 pci, which is then corrected to 150 pci based on the AASHTO 1993 graph.
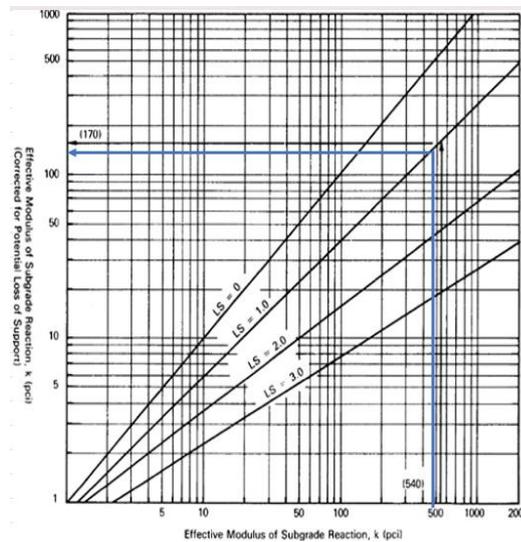

Figure 2. Soil modulus correction graph

The flexural strength of the concrete used is 45 kg/cm² (639,9 psi), and the compressive strength of the concrete is 450 kg/cm² (6399 psi), with the modulus of elasticity of the concrete (E_c) calculated as 4.559.643,74 psi using the formula $E_c = 57000 \times \sqrt{f'c}$. The thickness of the pavement is calculated using the equation:

$$\text{Log}_{10}\ W_{18} = Z_R \times S_o + 7{,}35 \times \text{Log}_{10}(D+1) - 0{,}06 + \frac{\text{Log}_{10}\left[\frac{\Delta Psi}{4{,}5-1{,}5}\right]}{1 + \frac{1{,}624\ \times\ 10^7}{(D+1)^{8.46}}} + (4{,}22 - 0{,}32 \times P_t) \times \text{Log}_{10}\frac{S'_c \times C_d \times [D^{0.75} - 1.132]}{215.63 \times J \times [D^{0.75} - \frac{18.42}{(E_c\ :\ k)^{0.25}}]}$$

by equating the left and right sides of the equation, resulting in the thickness of the concrete slab that meets the structural requirements of the pavement based on the planned traffic load, as shown in the following table.

Table 6. Calculation of pavement thickness using the AASHTO 1993 method

No.	Parameter	Value	Unit
1	Design Life	20	Years
2	Subgrade CBR	6	%
3	Concrete Compressive Strength	450	kg/cm²
4	Traffic Growth Rate (I)	4,88	%
5	Traffic Growth Factor (R)	32,65	
6	Lane Distribution Factor (D_L)	0,8	
7	Directional Distribution Factor (D_D)	0,5	
8	Cumulative ESAL (W_{18})	84.288.235,48	ESAL
9	Z_r Value	-1,282	

No.	Parameter	Value	Unit
10	Standard Deviation (S$_o$)	0,35	
11	Reliability	90	%
12	Serviceability	2	ΔPsi
13	Load Transfer Coefficient (J)	2,8	
14	Modulus Resilient (M$_R$)	9000	psi
15	Modulus of Subgrade Reaction	463,92	pci
16	Concrete Elastic Modulus (E$_c$)	4.559.643,74	psi
17	Concrete Flexural Strength (S'c)	639,9	psi
18	Drainage Coefficient (Cd)	1,25	
19	Pavement Thickness	28 cm (11.11 inch)	

From the above calculations, the thickness of the concrete slab is 11,11 inches or 280 mm. The pavement structure is equipped with a foundation layer consisting of 150 mm thick class A aggregate and 100 mm thick lean concrete. At the joints, tie bars with a diameter of D16 mm and a length of 762 mm are used, spaced at 600 mm intervals, along with dowels with a diameter of Ø32 mm and a length of 450 mm, spaced at 300 mm intervals.

B. Based on the MDPJ 2024 Method

Referring to the 2024 MDP guidelines, the following is the classification of vehicle types, axle configurations, axle groups, and vehicle numbers obtained from the 2026 ADT data [10].

Table 7. Vehicle group classification

Vehicle Group	Vehicle Type	Axis Configuration	Axis Group	Vehicle Count
1	Motorcycle and 3-wheel vehicles	1.1	2	
2	Light vehicles - sedan, jeep, and station wagon	1.1	2	26.573
3	Light vehicles - medium public transport	1.1	2	
4	Light vehicles - pick up, micro truck	1.1	2	8.176
5A	Small bus	1.1	2	3.679
5B	Large bus	1.2	2	2.453
6A	2-axle truck - light	1.1	2	2.984
6B	2-axle truck - medium	1.2	2	2.441
7A1	3-axle heavy truck	11.2	2	764
7A2	3-axle heavy truck	1.22	2	1.146
7A3	3-axle heavy truck	11.22	2	149
7B1	4-axle heavy truck	1.2+2.2	4	239
7B2	4-axle heavy truck	11.2+2.2	4	190
7B3	5-axle heavy truck	1.22+2.2	4	
7C1	4-axle heavy truck	1.2-22	3	209
7C2A	5-axle heavy truck	1.22-22	3	233
7C2B	5-axle heavy truck	1.2-222	3	
7C3	6-axle heavy truck	1.22-222	3	
7C4	7-axle heavy truck	1.22-2222	3	
8	Non-motorized vehicles	-	-	

Next, ADT data that only covers vehicles with a minimum weight of 5 tons is converted to JSKN using the vehicle axle configuration table in the guidelines, and the results are shown in the following table.

Table 8. Conversion results to JSKN

Vehicle Group	ADT	HVAG	JSKN$_{JK}$	STRT	STRG	STdRT	STdRG	STrRG	SQdRQ
5B	2.453	4.906	2	2.453	2.453	0	0	0	0
6A	2.984	5.967	2	5.967	0	0	0	0	0
6B	2.441	4.882	2	2.441	2.441	0	0	0	0
7A1	764	1.528	2	0	764	764	0	0	0
7A2	1.146	2.292	2	1.146	0	0	1.146	0	0
7A3	149	298	2	0	0	149	149	0	0
7B1	239	954	4	239	716	0	0	0	0
7B2	190	762	4	0	571	190	0	0	0
7B3	0	0	4	0	0	0	0	0	0
7C1	209	626	3	209	209	0	209	0	0
7C2A	233	698	3	233	0	0	466	0	0
7C2B	0	0	3	0	0	0	0	0	0
7C3	0	0	3	0	0	0	0	0	0
7C4	0	0	3	0	0	0	0	0	0
TOTAL	**10.807**	**22.914**	**39**	**12.687**	**7.154**	**1.103**	**1.969**	**0**	**0**
Proportion of Vehicle Types (%)		100,00		55,37	31,22	4,82	8,59	0,00	0,00

Next, for two-way roads, a direction distribution factor (D_D) of 0,5 and a lane distribution factor (D_L) of 80% are used, taken from the table of provisions according to the conditions of two lanes in each direction. With 365 days in a year and a daily JSKN value of 22,914, the total cumulative JSKN is calculated using the formula: $JSKN = (\sum ADT_{JK} \times JSKN_{JK}) \times 365 \times D_D \times D_L \times R$, yielding a result of 109.225.939,75 or equivalent to 11×10^7 JSKN. The type of rigid pavement structure used is jointed plain concrete pavement (JPCP) with a minimum flexural strength of 4.5 MPa (45 kg/cm²) and equipped with concrete shoulders. The bearing capacity of each layer consists of existing subgrade soil with a CBR of 6% and a 200 mm thick Class A aggregate foundation layer (LFA). Additionally, the structural design will incorporate a lower foundation layer of thin concrete with a thickness of 150 mm, as per the specifications in the guidelines. Based on the graph and the thickness of the lower foundation layer, the Effective Subgrade CBR value is determined to be 75%.
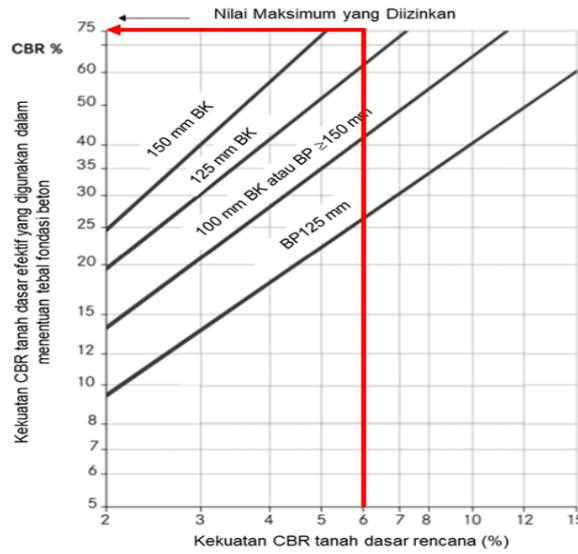
Figure 3. Effective subgrade CBR chart

The design of the JPCP rigid pavement for this project uses a reliability value of 90% and a load safety factor (L_{SF}) of 1,2. Based on the minimum slab thickness table in the MDJ 2024 guidelines, the minimum thickness of the concrete slab used is 250 mm. The load distribution data for commercial vehicle axle groups (JSKN) uses actual load data from the Jakarta - Cikampek II South Toll Road Section IIB project, which refers to West Java - Central Corridor data in accordance with Appendix D of the MDPJ 2024 guidelines. After obtaining the minimum thickness values, calculations were performed to determine the permitted load repetitions, adjusted for the vehicle axle group and the planned JSKN load distribution. The calculation results are presented in Tables 9 to 14.

Table 9. Permissible load repetition calculation results – STRT

STRT				
Axle Load (kN)	Load Proportion (%100)	Axle Group Proportion (%/100)	Traffic Design (JSKN)	Permitted Load Repetition
130	0,00	0,55	109.225.939,75	-
120	0,11	0,55	109.225.939,75	6.652.651,52
110	1,40	0,55	109.225.939,75	84.670.110,26
100	0,39	0,55	109.225.939,75	23.586.673,57
90	1,88	0,55	109.225.939,75	113.699.862,34
80	11,78	0,55	109.225.939,75	712.438.499,16
70	14,87	0,55	109.225.939,75	899.317.528,22
60	22,41	0,55	109.225.939,75	1.355.326.550,60
50	24,65	0,55	109.225.939,75	1.490.798.727,01
40	18,69	0,55	109.225.939,75	1.130.345.971,92
30	3,72	0,55	109.225.939,75	224.980.578,68
20	0,06	0,55	109.225.939,75	3.628.719,01
10	0,04	0,55	109.225.939,75	2.419.146,01

Table 10. Permissible load repetition calculation results - STdRT

STdRT				
Axle Load (kN)	Load Proportion (%100)	Axle Group Proportion (%/100)	Traffic Design (JSKN)	Permitted Load Repetition
30	0,00	0,05	109.225.939,75	-
20	0,00	0,05	109.225.939,75	-
10	0,00	0,05	109.225.939,75	-

Table 11. Permissible load repetition calculation results – STrTG

STrRG				
Axle Load (kN)	Load Proportion (%100)	Axle Group Proportion (%/100)	Traffic Design (JSKN)	Permitted Load Repetition
320	0,00	0,00	109.225.939,75	-
310	0,00	0,00	109.225.939,75	-
300	0,00	0,00	109.225.939,75	-

Table 12. Permissible load repetition calculation results – STdRG

STdRG				
Axle Load (kN)	Load Proportion (%100)	Axle Group Proportion (%/100)	Traffic Design (JSKN)	Permitted Load Repetition
320	0,03	0,09	109.225.939,75	281.613,56
310	0,50	0,09	109.225.939,75	4.693.559,34
300	0,49	0,09	109.225.939,75	4.599.688,16
290	0,92	0,09	109.225.939,75	8.636.149,19
280	1,31	0,09	109.225.939,75	12.297.125,48
270	1,38	0,09	109.225.939,75	12.954.223,79
260	3,22	0,09	109.225.939,75	30.226.522,17
250	3,15	0,09	109.225.939,75	29.569.423,86
240	4,46	0,09	109.225.939,75	41.866.549,34
230	4,73	0,09	109.225.939,75	44.401.071,38
220	3,86	0,09	109.225.939,75	36.234.278,13
210	3,76	0,09	109.225.939,75	35.295.566,26
200	4,79	0,09	109.225.939,75	44.964.298,50
190	3,66	0,09	109.225.939,75	34.356.854,39
180	4,09	0,09	109.225.939,75	38.393.315,42
170	6,02	0,09	109.225.939,75	56.510.454,49
160	3,55	0,09	109.225.939,75	33.324.271,33
150	4,63	0,09	109.225.939,75	43.462.359,52

	STdRG			
Axle Load (kN)	Load Proportion (%100)	Axle Group Proportion (%/100)	Traffic Design (JSKN)	Permitted Load Repetition
140	5,07	0,09	109.225.939,75	47.592.691,74
130	6,48	0,09	109.225.939,75	60.828.529,08
120	7,59	0,09	109.225.939,75	71.248.230,82
110	6,91	0,09	109.225.939,75	64.864.990,12
100	5,83	0,09	109.225.939,75	54.726.901,94
90	4,73	0,09	109.225.939,75	44.401.071,38
80	3,36	0,09	109.225.939,75	31.540.718,78
70	2,40	0,09	109.225.939,75	22.529.084,85
60	1,27	0,09	109.225.939,75	11.921.640,73
50	1,20	0,09	109.225.939,75	11.264.542,42
40	0,50	0,09	109.225.939,75	4.693.559,34
30	0,09	0,09	109.225.939,75	844.840,68
20	0,00	0,09	109.225.939,75	-
10	0,02	0,09	109.225.939,75	187.742,37

Table 13. Permissible load repetition calculation results – STRG

	STRG			
Axle Load (kN)	Load Proportion (%100)	Axle Group Proportion (%/100)	Traffic Design (JSKN)	Permitted Load Repetition
170	0	0,31	109.225.939,75	-
160	0,03	0,31	109.225.939,75	1.023.001,80
150	0,05	0,31	109.225.939,75	1.705.003,00
140	5,31	0,31	109.225.939,75	181.071.318,47
130	17,32	0,31	109.225.939,75	590.613.038,77
120	6,39	0,31	109.225.939,75	217.899.383,24
110	6,84	0,31	109.225.939,75	233.244.410,23
100	7,44	0,31	109.225.939,75	253.704.446,22
90	6,14	0,31	109.225.939,75	209.374.368,25
80	5,96	0,31	109.225.939,75	203.236.357,45
70	12,78	0,31	109.225.939,75	435.798.766,48
60	15,31	0,31	109.225.939,75	522.071.918,22
50	7,62	0,31	109.225.939,75	259.842.457,01
40	5,21	0,31	109.225.939,75	177.661.312,47
30	2,93	0,31	109.225.939,75	99.913.175,73
20	0,28	0,31	109.225.939,75	9.548.016,79
10	0,38	0,31	109.225.939,75	12.958.022,79

Table 14. Permissible load repetition calculation results – SQdRG

SQdRG				
Axle Load (kN)	Load Proportion (%100)	Axle Group Proportion (%/100)	Traffic Design (JSKN)	Permitted Load Repetition
30	0,00	0,00	109.225.939,75	-
20	0,00	0,00	109.225.939,75	-
10	0,00	0,00	109.225.939,75	-

Next, fatigue and erosion factors were calculated using a concrete thickness of 295 mm, yielding the results shown in the table below, where the total fatigue and erosion factors were both below 100%.

Table 15. Fatigue and erosion factor calculation results – STdRT

Axial Load (kN)	LSF Load Repetition (Design Load)	Permissible Load Repetition	Fatigue Factor Equivalence	0,66	Erosion Factor Equivalence	2,16
			Fatigue Factor Analysis		Erosion Factor Analysis	
			Permitted Repetitions	Fatigue (%)	Permitted Repetitions	Erosion (%)
30	36	0,00	0,00E+00	0,00	3,56E+14	0,00
20	24	0,00	0,00E+00	0,00	3,56E+14	0,00
10	12	0,00	0,00E+00	0,00	3,56E+14	0,00
Total			Fatigue (%)	0,00	Erosion (%)	0,00

Table 16. Fatigue and erosion factor calculation results – STdRG

Axial Load (kN)	LSF Load Repetition (Design Load)	Permissible Load Repetition	Fatigue Factor Equivalence	0,43	Erosion Factor Equivalence	2,16
			Fatigue Factor Analysis		Erosion Factor Analysis	
			Permitted Repetitions	Fatigue (%)	Permitted Repetitions	Erosion (%)
320	384	281.613,56	0,00E+00	0,00	7,45E+05	0,38
310	372	4.693.559,34	0,00E+00	0,00	9,49E+05	4,95
300	360	4.599.688,16	0,00E+00	0,00	1,23E+06	3,73
290	348	8.636.149,19	0,00E+00	0,00	1,64E+06	5,26
280	336	12.297.125,48	0,00E+00	0,00	2,26E+06	5,45
270	324	12.954.223,79	0,00E+00	0,00	3,23E+06	4,01
260	312	30.226.522,17	0,00E+00	0,00	4,88E+06	6,19
250	300	29.569.423,86	0,00E+00	0,00	8,01E+06	3,69
240	288	41.866.549,34	0,00E+00	0,00	1,50E+07	2,79
230	276	44.401.071,38	0,00E+00	0,00	3,63E+07	1,22
220	264	36.234.278,13	0,00E+00	0,00	1,90E+08	0,19
210	252	35.295.566,26	0,00E+00	0,00	3,56E+14	0,00
200	240	44.964.298,50	0,00E+00	0,00	3,56E+14	0,00
190	228	34.356.854,39	0,00E+00	0,00	3,56E+14	0,00

Axial Load (kN)	LSF Load Repetition (Design Load)	Permissible Load Repetition	Fatigue Factor Equivalence	0,43	Erosion Factor Equivalence	2,16
			Fatigue Factor Analysis		Erosion Factor Analysis	
			Permitted Repetitions	Fatigue (%)	Permitted Repetitions	Erosion (%)
180	216	38.393.315,42	0,00E+00	0,00	3,56E+14	0,00
170	204	56.510.454,49	0,00E+00	0,00	3,56E+14	0,00
160	192	33.324.271,33	0,00E+00	0,00	3,56E+14	0,00
150	180	43.462.359,52	0,00E+00	0,00	3,56E+14	0,00
140	168	47.592.691,74	0,00E+00	0,00	3,56E+14	0,00
130	156	60.828.529,08	0,00E+00	0,00	3,56E+14	0,00
120	144	71.248.230,82	0,00E+00	0,00	3,56E+14	0,00
110	132	64.864.990,12	0,00E+00	0,00	3,56E+14	0,00
100	120	54.726.901,94	0,00E+00	0,00	3,56E+14	0,00
90	108	44.401.071,38	0,00E+00	0,00	3,56E+14	0,00
80	96	31.540.718,78	0,00E+00	0,00	3,56E+14	0,00
70	84	22.529.084,85	0,00E+00	0,00	3,56E+14	0,00
60	72	11.921.640,73	0,00E+00	0,00	3,56E+14	0,00
50	60	11.264.542,42	0,00E+00	0,00	3,56E+14	0,00
40	48	4.693.559,34	0,00E+00	0,00	3,56E+14	0,00
30	36	844.840,68	0,00E+00	0,00	3,56E+14	0,00
20	24	-	0,00E+00	0,00	3,56E+14	0,00
10	12	187.742,37	0,00E+00	0,00	3,56E+14	0,00
Total			Fatigue (%)	0,00	Erosion (%)	37,85

Table 17. Fatigue and erosion factor calculation results – STRT

Axial Load (kN)	LSF Load Repetition (Design Load)	Permissible Load Repetition	Fatigue Factor Equivalence	0,66	Erosion Factor Equivalence	1,48
			Fatigue Factor Analysis		Erosion Factor Analysis	
			Permitted Repetitions	Fatigue (%)	Permitted Repetitions	Erosion (%)
130	156	-	9,14E+04	0,00	1,91E+07	0,00
120	144	6.652.651,52	3,21E+05	0,00	2,89E+08	0,02
110	132	84.670.110,26	2,47E+06	0,00	3,56E+14	0,00
100	120	23.586.673,57	0,00E+00	0,00	3,56E+14	0,00
90	108	113.699.862,34	0,00E+00	0,00	3,56E+14	0,00
80	96	712.438.499,16	0,00E+00	0,00	3,56E+14	0,00
70	84	899.317.528,22	0,00E+00	0,00	3,56E+14	0,00
60	72	1.355.326.550,60	0,00E+00	0,00	3,56E+14	0,00
50	60	1.490.798.727,01	0,00E+00	0,00	3,56E+14	0,00
40	48	1.130.345.971,92	0,00E+00	0,00	3,56E+14	0,00
30	36	224.980.578,68	0,00E+00	0,00	3,56E+14	0,00

Axial Load (kN)	LSF Load Repetition (Design Load)	Permissible Load Repetition	Fatigue Factor Equivalence	0,66	Erosion Factor Equivalence	1,48
			Fatigue Factor Analysis		Erosion Factor Analysis	
			Permitted Repetitions	Fatigue (%)	Permitted Repetitions	Erosion (%)
20	24	3.628.719,01	0,00E+00	0,00	3,56E+14	0,00
10	12	2.419.146,01	0,00E+00	0,00	3,56E+14	0,00
Total			Fatigue (%)	0,00	Erosion (%)	0,02

Table 18. Fatigue and erosion factor calculation results – STRG

Axial Load (kN)	LSF Load Repetition (Design Load)	Permissible Load Repetition	Fatigue Factor Equivalence	0,48	Erosion Factor Equivalence	2,08
			Fatigue Factor Analysis		Erosion Factor Analysis	
			Permitted Repetitions	Fatigue (%)	Permitted Repetitions	Erosion (%)
170	204	-	0,00E+00	0,00	9,63E+05	0,00
160	192	1.023.001,80	0,00E+00	0,00	1,58E+06	0,65
150	180	1.705.003,00	0,00E+00	0,00	2,88E+06	0,59
140	168	181.071.318,47	0,00E+00	0,00	6,24E+06	29,04
130	156	590.613.038,77	0,00E+00	0,00	1,95E+07	30,35
120	144	217.899.383,24	0,00E+00	0,00	3,13E+08	0,70
110	132	233.244.410,23	0,00E+00	0,00	3,56E+14	0,00
100	120	253.704.446,22	0,00E+00	0,00	3,56E+14	0,00
90	108	209.374.368,25	0,00E+00	0,00	3,56E+14	0,00
80	96	203.236.357,45	0,00E+00	0,00	3,56E+14	0,00
70	84	435.798.766,48	0,00E+00	0,00	3,56E+14	0,00
60	72	522.071.918,22	0,00E+00	0,00	3,56E+14	0,00
50	60	259.842.457,01	0,00E+00	0,00	3,56E+14	0,00
40	48	177.661.312,47	0,00E+00	0,00	3,56E+14	0,00
30	36	99.913.175,73	0,00E+00	0,00	3,56E+14	0,00
20	24	9.548.016,79	0,00E+00	0,00	3,56E+14	0,00
10	12	12.958.022,79	0,00E+00	0,00	3,56E+14	0,00
Total			Fatigue (%)	0,00	Erosion (%)	61,32

Table 19. Fatigue and erosion factor calculation results – STrRG

Axial Load (kN)	LSF Load Repetition (Design Load)	Permissible Load Repetition	Fatigue Factor Equivalence	0,30	Erosion Factor Equivalence	2,17
			Fatigue Factor Analysis		Erosion Factor Analysis	
			Permitted Repetitions	Fatigue (%)	Permitted Repetitions	Erosion (%)
30	36	0,00	0,00E+00	0,00	3,56E+14	0,00
20	24	0,00	0,00E+00	0,00	3,56E+14	0,00

10	12	0,00	0,00E+00	0,00	3,56E+14	0,00
	Total		Fatigue (%)	0,00	Erosion (%)	0,00

Table 20. Fatigue and erosion factor calculation results – SQdRG

Axial Load (kN)	LSF Load Repetition (Design Load)	Permissible Load Repetition	Fatigue Factor Equivalence	0,30	Erosion Factor Equivalence	2,17
			Fatigue Factor Analysis		Erosion Factor Analysis	
			Permitted Repetitions	Fatigue (%)	Permitted Repetitions	Erosion (%)
30	36	0	0,00E+00	0,00	0,00E+00	0,00
20	24	0	0,00E+00	0,00	0,00E+00	0,00
10	12	0	0,00E+00	0,00	0,00E+00	0,00
	Total		Fatigue (%)	0,00	Erosion (%)	0,00

Based on the analysis results, the appropriate concrete thickness to withstand traffic loads in the rigid pavement design was determined to be 295 mm (with a total fatigue factor of 00,00% and an erosion factor of 99,19%). The concrete pavement is designed as a jointed plain concrete pavement (JPCP) with a slab width of 2 × 3,5 meters and a slab length of 5 meters, where shrinkage joints are installed every 5 meters. The dowels used are plain steel with a diameter of 38 mm, a length of 45 cm, and a spacing of 30 cm between dowels, in accordance with the guidelines. Meanwhile, the tie bars use threaded steel bars with a diameter of 16 mm and a length of 70 cm, installed at a spacing of 60 cm.

From the two methods described above, a comparison can be made between the calculated thickness of the pavement structure and the actual thickness of the structure in the field, as shown in the following table:

Table 21. Comparison results

Material	AASHTO 1993 (mm)	MDPJ 2024 (mm)	Field Data (mm)
Class A aggregate layer	150	200	150
Lean concrete foundation layer	100	150	100
Concrete slab Fs 45 kg/cm²	280	295	300
Dowel	Ø32-300, L=450	Ø38-300, L=450	Ø32-300, L=450
Tie bar	D16-600, L=762	D16-600, L=700	D16-600, L=700

C. Unit Price Analysis

Unit price analysis was conducted to compare the cost efficiency between the AASHTO 1993 and MDPJ 2024 pavement methods. Calculations were performed for a single pavement segment measuring 5 meters in length and 9,3 meters in width on the Jakarta - Cikampek II South Toll Road Section IIB project, which includes an A-class aggregate base layer, wet lean concrete, and cement concrete pavement.

Unit price data was obtained from the 2023 AHSP of PT. Adhi – Acset KSO and adjusted to 2025 using an inflation factor of 1,6% (2024) and 0,11% (2025), based on data from the Bekasi City Statistics Agency. Additionally, material requirements such as dowels and tie bars were calculated based on the design thickness of each method.

The calculation results show that the total cost for one pavement segment using the 1993 AASHTO method is Rp26.805.934,05, while the 2024 MDPJ method reaches Rp30.154.064,25. The total construction cost estimate for the 13 km road is calculated by dividing the cost per

segment by the segment length (5 meters), then multiplying by the total road length (13.000 meters), and multiplying by two because this toll road consists of two lanes. This process resulted in an estimate of the total cost of the Unit Price Analysis for the entire toll road construction. Based on these results, the total estimated cost using the 1993 AASHTO method is Rp139.390.857.060,00, while the 2024 MDPJ method produces a higher cost, which is Rp156.801.134.100,00.

CONCLUSION

The results of this analysis show that the type of rigid pavement used in the Jakarta - Cikampek II South Section IIB Toll Road project is continuous rigid pavement without reinforcement. Calculations using the AASHTO 1993 method resulted in a concrete slab thickness of 11.11 inches or 28 cm. Transverse joints are planned to use Ø32 mm dowels spaced 300 mm apart and 450 mm long, along with D16 mm tie bars spaced 600 mm apart and 762 mm long, with a 10 cm thick lean concrete layer and a 15 cm thick Class A aggregate layer. Meanwhile, the MDPJ 2024 method produces a concrete slab thickness of 29.5 cm, with dowels of Ø38 mm spaced at 300 mm intervals and a length of 450 mm, as well as tie bars of D16 mm spaced at 600 mm intervals and a length of 700 mm, accompanied by a lean concrete layer of 15 cm thickness and an aggregate layer of Class A material with a thickness of 20 cm. From the total cost analysis for a 13 km section, it was found that the pavement using the AASHTO 1993 method is more economical than the MDPJ 2024 method, with a cost difference of Rp17.410.277.040,00. The analysis conducted has answered the research objectives and provided a comparative overview of the design and cost efficiency of the two rigid pavement methods. This study contributes to the selection of an efficient design method, although it does not yet include structural strength analysis. Therefore, further research is recommended to include strength analysis using software, as well as considering maintenance and operational costs for a more accurate life cycle cost estimate.

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