

Design of Provincial Road Pavement Thickness Based on Pavement Design Manual (MDP) 2024 (Case Study: Cileungsi - Cibinong Road Section)

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Abstract

Roads are one of the most important land transportation infrastructure, so good pavement design is a must to connect one place to another. This study aims to determine the type and thickness of the pavement structure used on the Cileungsi - Cibinong road section based on the Pavement Design Manual (MDP) 2024. The research location was carried out on the road section. Cileungsi - Cibinong, West Java with a road length of 14.72 km. The planned life using the Pavement Design Manual (MDP) 2024 is for 20 years with a traffic growth rate factor of 3.50% and obtained a Cumulative Equivalent Single Axle (CESA) value of 4.5×10^6 with AC-WC 40mm, AC-BC 65mm and 80mm thick, LFA 200mm and LFB 150mm.

Keywords: Highway, Pavement Structure, MDP 2024.

1. INTRODUCTION

Along with the times and the increase in population in Indonesia, economic activities and daily activities of the community also encourage an increase in the number of vehicles operating. This condition is the impact of the intensity of human interaction in various sectors of life. The increase in the number of vehicles causes problems such as traffic congestion and physical damage to road infrastructure in various regions. Recognizing the importance of a smooth and comfortable transportation system for the community, the government continues to strive to improve the quality of transportation in Indonesia through various programs, such as repairing, widening, and building new roads. Along with the increasing development of road infrastructure to support economic activities and community needs, the demand for basic road construction materials has also increased significantly.

1.1. Road Pavement

Pavement plays an important role in distributing vehicle loads to the subgrade to ensure user comfort and safety. There are three types of pavement, namely flexible (asphalt-based), rigid (concrete slab), and composite (combination of both). The selection is based on traffic volume, subgrade conditions, cost efficiency, and the planned life of the road (4).

1.1.1. Types of Pavement Layers and Their Functions

Flexible pavement construction consists of layers that are placed on a compacted subgrade. These layers function to receive the traffic load and spread it to the layers below.

- 1) Surface Layer
- 2) Upper foundation layer
- 3) Lower foundation layer
- 4) Subgrade layer (7).

1.1.2. Pavement Design Manual 2024

The Methods of Pavement Design Manual Number 03/M/BM Year 2024 was published as a revision and replacement of the 2017 edition of the MDP. This document implements a mechanistic-empirical approach in planning pavement structures, for both flexible and rigid pavement types, with the result being a catalog of pavement structures. The approach combines the mechanistic principles of structural analysis with empirical data

to more accurately predict the long-term performance of pavements. Compared to the previous edition, MDP 2024 includes a number of significant updates, including the removal of the term capping layer, recommendations on the application of geotechnical analysis for soils with problematic characteristics that have a thickness of more than one meter, as well as adjustments in the traffic plan calculation method. In addition, the standard reliability value was set at a constant 90%, and adjustments were made to the design charts in the pavement catalog to align with the capabilities of compaction equipment in the field (3).

1.2. Plan Life

The life expectancy of a road is the time from when the road is in use until it needs to be overlaid. The choice of pavement type will vary according to the estimated traffic, plan life, and condition of the road foundation.

Table 1. Plan Life

| Pavement Type | Pavement Element | Plan Life (years) |
|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-------------------|
| Flexural Pavement | Asphalt and graded layers | 20 |
| | Road Foundation Layer | |
| | All pavements for locations where overlays are not possible such as: urban roads, underpasses, bridges and tunnels | 40 |
| Cement-Bonded Foundation Layer, Cement Treated Based (CTB) | | |
| Rigid Pavement | Top foundation layer, bottom foundation layer, cement concrete layer, and road foundations | |
| Road without cover | All elements (including road foundations) | 10 |

Source : MDP 2024

The design life of flexible pavement should be adjusted to the functional capacity of the road. If the plan life in Table 1 is deemed inappropriate, then an alternative life may be used provided that it is supported by a discounted life-cycle cost analysis that shows the lowest total cost over the service life. This analysis should use Bank Indonesia average interest rates from official sources, to ensure economic efficiency in determining the plan life. (5).

1.3. Traffic

1.3.1. Traffic Volume Analysis

In the analysis of pavement structures, traffic parameters have a very crucial role, as they form the basis for determining the plan load that the pavement structure will receive throughout its service life (6). Load estimation is based on the traffic volume at the time of the survey, and then projected to reflect conditions over the life of the plan. The first year traffic volume is the total vehicles passing over the pavement in the first year after construction or rehabilitation is completed.

1.3.2. Traffic on Plan Lanes

The plan lane is the lane with the largest volume of commercial vehicles (trucks and buses) on a road section. The traffic load in this lane is expressed as cumulative standard axle load (CESA), taking into account the directional distribution (DD) and lane distribution (DL) factors. The accuracy of traffic data is essential to produce an efficient and justifiable pavement design (2). The data should include all types of commercial vehicles on the surveyed road section. If the data is inaccurate, additional traffic analysis should be conducted so that the load estimates reflect the actual conditions in the field.

1.3.3. Vehicle Type

In the MDP 2024 Method, the types of vehicles that are taken into account in pavement design must at least meet the classification of class 5B vehicles or Large Buses. While light to medium vehicles, which are classified as class 1 to class 4 vehicles, are not taken into account in pavement design, because they have a small enough axle load that they do not have the potential to cause damage to the pavement structure (3).

1.3.4. Traffic Growth Factor

Traffic growth factors can be determined based on historical growth data or through correlation analysis with other relevant and applicable growth factors. If historical data is not available, traffic growth is estimated by referring to standard values according to regions in Indonesia as listed in Table 2.

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

| Road Type | Java | Sumatra | Kalimantan | Indonesia Average |
|--------------------|------|---------|------------|-------------------|
| Arterial and urban | 4,80 | 4,83 | 5,14 | 4,75 |
| Rural collectors | 3,50 | 3,50 | 3,50 | 3,50 |
| Village road | 1,00 | 1,00 | 1,00 | 1,00 |

Source : MDP 2024

Calculation of traffic growth over the life of the plan with a cumulative growth factor using equation 1.

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

With :

R = kumulatif Cumulative traffic growth multiplier factor

i = Annual traffic growth rate (%)

UR = Plan Life (years)

1.3.5. Traffic on the Plan Lane

The plan lane refers to the traffic lane in a road section that receives the largest commercial vehicle loads, such as large trucks and buses. The traffic load on this plan lane is calculated in the form of cumulative standard axle load (ESA), with adjustment through two distribution parameters, namely directional distribution factor (DD) and commercial vehicle lane distribution factor (DL). For roads with two directions of traffic, the DD value is generally assumed to be 0.50 except in special conditions where there is significant commercial vehicle dominance in one particular direction (3).

Table 3 Directional Distribution Factor (DL)

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

Source : MDP 2024

1.4. Cumulative Standard Axis Load

In MDP 2024, traffic loads are converted into equivalent standard axle (ESA) loads through the use of the Vehicle Damage Factor (VDF), which represents the total ESA of all vehicle axes. The VDF allows the integration of different vehicle types into a cumulative ESA unit. The analysis of the pavement structure is based on the accumulated total ESA over the plan life of a particular traffic lane (1). Therefore, proper estimation of traffic load is crucial. Systematically designed and conducted axle load surveys are the main basis for obtaining reliable ESA data (3).

MDP 2024 presents the regional Vehicle Damage Factor (VDF) values for each commercial vehicle class in each province, which can be used as a reference in flexible pavement design planning. Specifically for West Java Province, the VDF values have been determined and presented as listed in Table 4.

Table 4 VDF Value of Each Vehicle Type for West Java - Central Crossing

| Condition | Vehicle Class | Gol 5B | Gol 6A | Gol 6B | Gol 7A2 | Gol 7C1 | Gol 7C2A | Gol 7C2B | Gol 7C3 |
|-----------|---------------|--------|--------|--------|---------|---------|----------|----------|---------|
| VDF4 | Factual | 1,2 | 0,5 | 3,5 | 5,7 | 4,0 | 2,6 | 4,1 | 4,4 |
| | Normal | 1,2 | 0,5 | 1,1 | 3,1 | 2,9 | 2,0 | 4,0 | 4,2 |
| VDF5 | Factual | 1,3 | 0,4 | 4,9 | 9,2 | 5,5 | 3,5 | 5,4 | 5,6 |
| | Normal | 1,3 | 0,4 | 1,0 | 4,0 | 3,5 | 2,2 | 5,2 | 5,3 |

Source : MDP 2024

1.5. Load Equivalent Factor (Vehicle Damage Factor)

Cumulative Equivalent Single Axle Load (CESAL) is the total accumulation of commercial vehicle axle load on the plan lane during the pavement service life. This value is obtained through calculations based on the Vehicle Damage Factor (VDF) for each type of commercial vehicle, the average daily traffic volume, as well as the direction distribution factor and lane distribution. CESAL reflects the actual load that must be carried by the pavement structure, so it is a key parameter in determining the thickness and resistance of the pavement to repeated traffic loads. The CESAL value is calculated using Equation 2. (3).

$$CESAL = (\Sigma LHRJK \times VDFJK) \times 365 \times DD \times DL \times R \quad (2)$$

Description:

- LHRJK = Average daily traffic of each type of commercial vehicle (units of vehicles per day)
VDFJK = load factor (vehicle damage factor) for each type of commercial vehicle
DD = Directional distribution factor
DL = Lane distribution factor
CESAL = Cumulative equivalent standard axle load over the plan life
R = Cumulative traffic growth multiplier

2. METHOD

2.1. Research Location

The research location was carried out on the Cileungsi - Cibinong road section in Bogor Regency, West Java with a road length of 14.72 km.

2.2. Research Reference

In calculating the thickness of the pavement layer on provincial roads using the 2024 Road Pavement Design Manual (MDP).

2.3. Research Data

The data used in this study are primary data and secondary data. The primary data is in the form of calculations to determine the design of pavement thickness. Meanwhile, secondary data is in the form of Average Daily Traffic data obtained from our lecturers.

3. RESULTS AND DISCUSSION

3.1. Planning Data

The data used in this study used secondary data for the Cileungsi - Cibinong Road section, as presented in Table 5. and Table 6.

Table 5 Flexural Pavement Thickness Planning Data

| No. | Data Description | |
|-----|-------------------------------------------------|-------------------------------------|
| 1 | Age Plan | 20 years |
| 2 | Road Type | Two-way One Lane Undivided (1/2 TT) |
| 3 | Vehicle direction distribution factor (D_D) | 50% |
| 4 | Lane-deployment factor (1 lane 2-way) (D_L) | 80% |
| 5 | Traffic Growth/Year | 3,5% |

Source: Data Analysis, 2025

The following is the LHRT data in 2024 for the Cileungsi - Cibinong Road section in West Java.

Table 6 Recapitulation of Average Daily Traffic (LHR) Data

| Vehicle Type | Vehicle Class | 2024 LHR Data |
|----------------------------------------------------|---------------|---------------|
| Motorcycles and 3-wheeled vehicles | 1 | 19.119 |
| Light vehicles - sedans, jeeps, and station wagons | 2 | 5.723 |
| Light vehicles - medium public transportation | 3 | 5.110 |
| Light vehicles - pick-ups and micro trucks | 4 | 1.348 |
| Small buses | 5A | 95 |
| Large Bus | 5B | 56 |
| 2-axis truck - light truck | 6A | 273 |
| 2-axis truck - medium truck | 6B | 322 |
| 3-axis truck - heavy | 7A1 | 344 |
| 3-axis truck - heavy | 7A2 | 147 |
| Non-motorized vehicles | 8 | 267 |

Source: Data Analysis, 2025

3.2. Pavement Thickness

From the calculation of CESA5, the value of CESA5 is 4.5×10^6 , then the value is entered into the pavement design table where the value from the table is obtained to determine the thickness of the pavement layer: Design Chart-3A Flexural pavement design - asphalt with aggregate foundation layer (asphalt pen 60/70 and PG70).

Table 7 Design Chart-3A Flexural pavement design - asphalt with aggregate foundation layer (asphalt pen 60/70 and PG70)

Bagan Desain-3A Desain perkerasan lentur – aspal dengan lapis fondasi agregat (aspal pen 60/70 dan PG70)

| Beban rencana 20 tahun (10 ⁶ ESA5) | STRUKTUR PERKERASAN | | | | | | | | |
|----------------------------------------------------------------------------------------|----------------------------------------------------------------|----------|----------|-----------|-----------|-------------------------------------------------------------------------------------------|------------|-------------|-------------|
| | FFF(1) 1 | FFF(1) 2 | FFF(1) 3 | FFF(1) 4 | FFF(1) 5 | FFF(1) 6 | FFF(1) 7 | FFF(1) 8 | FFF(1) 9 |
| | Untuk beban rencana < 30 juta ESA5 menggunakan Aspal Pen 60-70 | | | | | Untuk beban rencana ≥ 30 juta ESA5 direkomendasikan menggunakan Aspal PG70 ⁽¹⁾ | | | |
| | < 2 | > 2 - 5 | > 5 - 10 | > 10 - 15 | > 15 - 30 | > 30 - 50 | > 50 - 100 | > 100 - 150 | > 150 - 200 |
| | Tebal Perkerasan (mm) | | | | | | | | |
| AC WC | 60 ⁽²⁾ | 40 | 40 | 40 | 40 | 40 | 40 | 50 | 40 |
| AC BC | - | 65 | 75 | 75 | 80 | 80 | 75 | 80 | 80 |
| | - | 80 | 80 | - | - | - | - | - | - |
| AC Base ⁽³⁾ | - | - | - | 100 | 80 | 85 | 100 | 100 | 80 |
| | - | - | - | - | 80 | 100 | 100 | 100 | 80 |
| | - | - | - | - | - | - | - | - | 90 |
| Lapis Fondasi Agregat Kelas A ⁽⁴⁾ | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Lapis Fondasi Agregat Kelas B | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| Timbunan Pilihan Berbutir Kasar atau LFA Kelas C atau Stabilisasi Semen ⁽⁵⁾ | - | - | 200 | 200 | 200 | 200 | 200 | 200 | 200 |

(1) Khusus untuk AC WC dan AC BC.
 (2) Tumbukan Marshall sebanyak 2 x 50 tumbukan.
 (3) Khusus untuk AC Base dengan lalu lintas rencana di atas 30 juta ESA5 dapat tidak menggunakan aspal PG70.
 (4) Untuk perkerasan dengan jumlah lajur lebih dari 2 per arahnya, tebal lapis fondasi agregat kelas A minimal 300 mm.
 (5) Dapat menggunakan timbunan pilihan berbutir kasar yang mempunyai CBR minimum 30% dengan PI 6 - 15 dan ukuran butir maksimum 50 mm atau LFA Kelas C atau stabilisasi semen (UCS 10 kg/cm²). Bilamana untuk ketiga jenis material atau alat yang diperlukan untuk stabilisasi tidak bisa terpenuhi, maka lapisan ini dapat diganti menjadi LFA Kelas B dengan ketebalan 200 mm bila harganya sama atau lebih rendah dari ketiga material tersebut.

Table 8 Pavement Layers (Flexural Pavement with LFA)

| Layer | Material | Layer Thickness (mm) |
|----------------------------|------------------|----------------------|
| AC WC | Asphalt Concrete | 40 |
| AC BC | Asphalt Concrete | 65 |
| | Asphalt Concrete | 80 |
| Aggregate Foundation Layer | LFA class A | 200 |
| | LFA grade B | 150 |

Source: Data Analysis, 2025

The results of the analysis of the pavement structure of the Cileungsi - Cibinong Road Section with a plan life of 20 years, and the cumulative amount of design traffic axis load during the plan life of 4.5 x 10⁶ CESA5, the thickness of each pavement layer is obtained as shown in Figure 1.

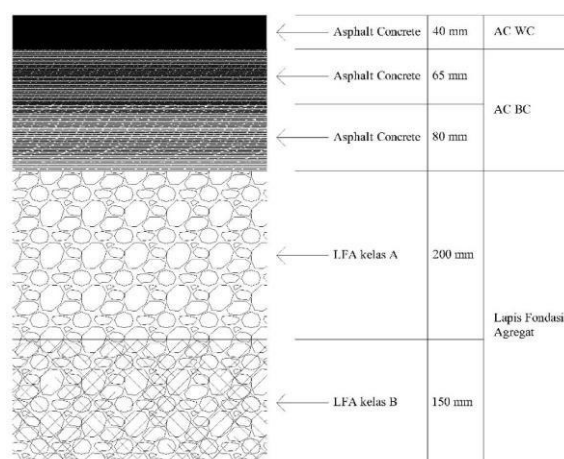


Figure 1 Pavement Layer (Flexural Pavement with LFA)

Source: Data Analysis, 2025

4. CONCLUSION

The thick pavement design for the Cileungsi - Cibinong road section using the MDP 2024 method obtained a Cumulative Equivalent Single Axle (CESA) value of 4.5x10⁶ with AC-WC 40mm, AC-BC 65mm and 80mm thick, LFA 200mm and LFB 150mm.

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