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Evaluation of Flexible Pavement Using the 2017 Bina Marga Method Study on Darul Hikmah Street, Terong Tawah, Labuapi District

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ABSTRACT

Flexible pavement utilises asphalt as a binding agent. The pavement layer transmits and distributes the weight from the road or flexible pavement uniformly onto the compacted subgrade. Damage to flexible pavement results from a confluence of multiple connected factors. The purpose of the study is to ascertain the thickness of flexible pavement layers and the various forms of flexible pavement. This research employs the 2017 Bina Marga approach, utilising predicted LHR data over the design life or LHRT, to ascertain the kind and thickness of flexible pavement layers, considering the CESA4 and CESA5 values. The 2044 LHRT value for Passenger Cars and Other Light Vehicles is 33,358.7; Class 5A is 6.2; Class 5B is 4.1; Class 6A is 17.1; Class 6B is 39.1; and Class 8 or non-motorized vehicles is 280.1. The CESA4 value derived from the LHRT value was 4021566.47, whereas the CESA5 value was 469755.421. The most preferred type and thickness of flexible pavement is asphalt with a granular foundation layer, namely AC – WC pavement type at 4 cm thickness, AC – BC at 6 cm thickness, and LFA Class A at 40 cm thickness.

INTRODUCTION

Roads are land infrastructure that is very important in facilitating economic relations and other social relations (Nugroho, 2022). However, if damage occurs to this infrastructure, in addition to hampering economic and social activities, it can also cause accidents for road users. For the safety and comfort of drivers, roads with proper pavement are needed (Maria et al., 2020). Pavement is a layer of roadway situated between the subsoil and the vehicle wheels, utilised for transportation purposes (Budiyanto et al., 2024). Road pavement is classified into two categories: flexible pavement and rigid pavement. In road pavement design, various elements contribute to road degradation (Israil, 2024). Factors causing road damage include the nature of the subsoil and high traffic volume, so that the pavement layer can be damaged or damaged over time before reaching the planned age (Anugrah, 2022).

This study is a replication of previous researchers, namely Silva, (2022), the study was conducted on Jalan Darul Hikmah, Terong Tawah, Kec. Labu Api, West Lombok. The difference between this study and previous studies lies in the object and period of the study, as well as environmental conditions (Rasidi et al., 2024). In addition, the research to be carried out has several differences related to the objectives where the previous study only sought to find out the type of damage that occurred on the flexible surface that occurred on Jalan Darul Hikmah, Terong Tawah, Kec. Labu Api, West Lombok (Wardhani, 2024). While this study will find out the thickness of the efficient flexible pavement according to Bina Marga 2017 (Rizki et al., 2022).

This research was conducted on Jalan Darul Hikmah, Terong Tawah, Kec.Labu Api, West Lombok, which is located next to Lapangan Karang Genteng, which is a connecting road between Mataram and West Lombok (Paikun et al., 2020). This road has a relatively high traffic volume because it is an alternative access road for public transportation such as garbage trucks, private cars, and material handling vehicles (Yuniarti et al., 2022). At several points, this road has experienced quite severe damage, making drivers uncomfortable, such as potholes (Djuhana et al., 2021).

The Darul Hikmah road section is a route with relatively high traffic volume, causing the road to experience damage to the flexible layer (Usman et al., 2018). The primary focus of this study is to assess flexible pavement utilising the 2017 Bina Marga methodology. This method enables researchers to ascertain the thickness of flexible pavement in accordance with the Bina-Marga method and to identify the discrepancy between field measurements and the findings of this study.

RESEARCH METHODS

The study was carried out in Jalan Darul Hikmah Terong Tawah, situated in the Labu Api District of West Lombok Regency, West Nusa Tenggara. The examined road measures 2.51 kilometres in length and 3.6 meters in width.

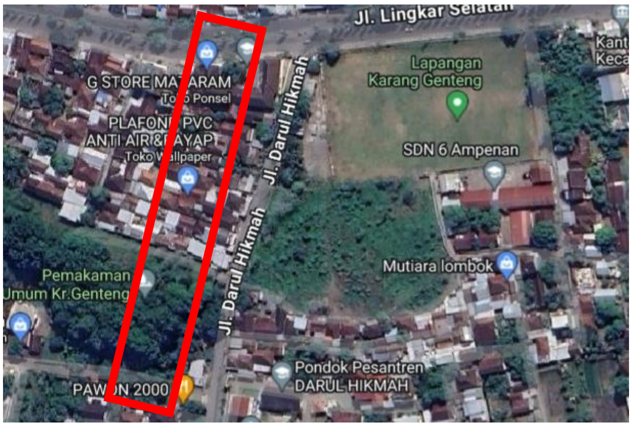

Figure 1. Research Location

To calculate the number of vehicles passing on the road when taking LHR data, the Traffic Counter Application is used. Traffic Counter Application. As below:

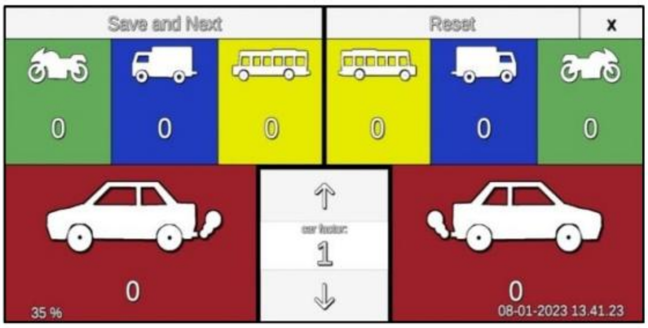

Figure 2. Traffic Counter Application

Research form, used for writing calculation results (Arifin et al., 2023). The 2017 Bina Marga method to determine the type of damage uses the LHR value or (Average Daily Traffic) which includes several things such as LHR calculations are carried out for 3 days, namely Monday, Thursday, and Sunday. LHR calculations are carried out at 3 different times each day, namely in the morning at 07.00-10.00, afternoon at 11.00-14.00, and evening at 15.00-18.00, LHR calculations are carried out at 2 different points, the first point or the direction from North to South, and the second point or the direction from South to North. To calculate LHR at both locations, four surveyors are necessary: Surveyor A and Surveyor B document the initial point or the orientation from North to South, with Surveyor A responsible for enumerating vehicles classified as 1, 2, and 4. Surveyor B is assigned to document and tally automobiles in categories 5a through 8. Surveyor C and Surveyor D document at the second point, orientated from South to North, where Surveyor C is responsible for enumerating cars classified as 1, 2, and 4. Surveyor D is assigned to document and enumerate cars in categories 5a to 8. Secondary data refers to information acquired from pre-existing data sources, including institutions, literature, reports, and journals. The secondary data utilised in this study consists of field sketches. The data will be utilised to substantiate primary data. This study requires standard design data from Bina Marga of West Nusa Tenggara Province as secondary data (Choiri et al., 2024).

RESULTS AND DISCUSSION

Average Daily Traffic

To determine the traffic volume on Jalan Darul Hikmah, Terong Tawah, Kec. Labu Api, Kab. Lombok Barat, direct observation was conducted over three days on Monday, Thursday, and Sunday at two points and in different directions. The calculation involves determining the **LHR (Average Daily Traffic) Calculation Results Per Day (for two directions).**

Monday

LHR = Total Vehicles on Monday from North – South + Total Vehicles on Monday from South – North

LHR = 6231 + 7009 = 13430 Kend /Jam

Thursday

LHR = Total Vehicles on Thursday from North – South + Total Vehicles on Thursday from South – North

LHR = 7192 + 9174 = 16366 Kend /Jam

Sunday

LHR = Total Sunday Vehicles from North – South + Total Sunday Vehicles from South – North

LHR = 5080 + 5572 = 10652 Kend /Jam

Among Monday, Thursday, and Sunday, Thursday experiences the highest traffic volume, with 16,366 cars, due to the significant resident population and Jalan Terong Tawah serving as an alternative route from the Labu Api area in West Lombok to the Mataram area. Since Thursday has the busiest number of vehicles, the LHRT value is calculated from Thursday's data to determine CESA4 and CESA5. Where the recapitulation of LHR data on Thursday can be seen in Table 1 below.

Calculation of Annual Traffic Growth Until the Design Age, 20 Years (LHRT)

LHR data on Thursday (Table 4.8) which is used as data to calculate LHRT from 2025 to 2044 and LHRT data 2044 which will be used to calculate CESA4 and CESA5. Where the calculation of LHRT is described in the following calculation.

$$\text{LHRT2044 (light vehicle)} = LHRo\ (1 + i)^{n}$$

$$= LHR_{2024}\ (1 + i(tabel\ 4.11)^{n\ (tahun\ ke-)}$$

$$= 16198(1 + 0{,}035)^{20}$$

$$= 33358.7\ \text{vehicles/day}$$

LHRT2044 (5a) $= LHRo\ (1 + i\ )^{n}$

$= LHR_{2024}\ (1 + i(tabel\ 4.11\ )^{n\ (tahun\ ke-)}$

$=16198(\ 1 + 0{,}035\ )^{20}$

= 6.2 vehicles/day

LHRT2044 (5b)= $LHRo\ (1 + i\ )^{n}$

$= LHR_{2024}\ (1 + i(tabel\ 4.11\ )^{n\ (tahun\ ke-)}$

$=16198(\ 1 + 0{,}035\ )^{20}$

= 4.1 vehicles/day

LHRT2044 (6a)= $LHRo\ (1 + i\ )^{n}$

$= LHR_{2024}\ (1 + i(tabel\ 4.11\ )^{n\ (tahun\ ke-)}$

$=16198(\ 1 + 0{,}035\ )^{20}$

= 17.1 vehicles/day

LHRT2044 (6b)= $LHRo\ (1 + i\ )^{n}$

$= LHR_{2024}\ (1 + i(tabel\ 4.11\ )^{n\ (tahun\ ke-)}$

$=16198(\ 1 + 0{,}035\ )^{20}$

= 39.1 vehicles/day

LHRT2044 (8)= $LHRo\ (1 + i\ )^{n}$

$= LHR_{2024}\ (1 + i(tabel\ 4.11\ )^{n\ (tahun\ ke-)}$

$=16198(\ 1 + 0{,}035\ )^{20}$

= 280.1 vehicles/day

LHRT Total 2044 = LHRT2044 (lightweight) + LHRT2044 (5a) + LHRT2044 (5b) + LHRT2044 (6a) + LHRT2044 (6b) + LHRT2044 (8)

= 33358.7 + 6.2 + 4.1 + 17.1 + 39.1 + 280.1

= 33705,232 vehicles/day

Average Daily Traffic Recapitulation According to Axle Configuration

The weight of passenger and light to medium cars is deemed to exert minimal influence on flexible pavement deterioration. Commercial vehicles with six or more wheels are seen as capable of damaging flexible pavement; therefore, they are included in the analysis, given the intended lifespan of 20 years. (Bina Marga 2017), the data used is LHRT 2044 (Adly et al., 2019). The recapitulation of average daily traffic is stated in Table 1.

Table 1. Average Daily Traffic Recapitulation

Vehicle type	Average Daily Traffic (2 lanes)	Information
Passenger cars and other light vehicles	33358.7	-
5A	6.2	Small Bus
5B	4.1	Big Bus
6A	17.1	2 Axle Light Truck
6B	39.1	2 Axle Heavy Truck
8	280.1	Non-Motorized Vehicles

Source: 2024 Calculation Results

Traffic Growth Factors (i)

Jalan Darul Hikmah, Terong Tawah, Kec. Labu Api is a thoroughfare linking Mataram to West Lombok. The road is designated as a Rural Collector, serving to facilitate the collection and distribution of transportation between residential areas in the village and connecting to local routes. Jalan Darul Hikmah, Terong Tawah, Kec. Labu Api is a thoroughfare linking Mataram to West Lombok. The road is designated as a Rural Collector, serving to facilitate the collection and distribution of transportation between residential areas in the village and connecting to local routes (Rahmawati & Adiyasa, 2021). Where the traffic growth rate factor (i) is stated in Table 2 below.

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

	Java	Sumatra	Kalimantan	Indonesian Average
Arteries and urban	4.80	4.83	5.14	4.75
Rural Collector	3.50	3.50	3.50	3.50
Village Road	1.00	1.00	1.00	1.00

Source: Highways 2017

Based on Bina Marga 2017, the average traffic growth rate factor in Indonesia in the Rural Road classification is taken at 3.50%. To calculate the traffic growth value throughout the design life, it is calculated using the cumulative growth factor.

It is known:

Traffic growth rate factor (i) = 3.50% = 0.035

Plan age = 20 Years

Formula used:

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

Answered:

$$R\ (2024 - 2044) = \frac{(1+0{,}01 \times i\,)^{UR} - 1}{0{,}01\, i}$$

$$= \frac{(1 + 0{,}01 \times 0{,}035\,)^{20} - 1}{0{,}01 \times 0{,}035}$$

= 20.07

So R or the cumulative traffic growth multiplier for 20 years from 2024 – 2044 is 20.07.

Lane Distribution Factor

The direction distribution factor (DD) is generally taken as 0.50 for two-way roads. Meanwhile, the lane distribution factor (DL) is stated in Table 2 below.

Table 3. Lane Distribution Factors

Number of Lanes in Each Direction	Commercial vehicles on design lane (% of commercial vehicle population)
1	100
2	80
3	60
4	50

Source: Highways 2017

Because Jalan Darul Hikmah is a 1 lane road with 2 lanes with each lane having one direction, the lane distribution (DL) value is 100% (1).

VDF (Vehicle Damage Factor) value

Uncontrolled factual loads are expected to persist until 2020. After 2020, the loads used are normal loads. VDF is divided into VDF4 and VDF5, which will later differentiate the results of the Cumulative Standard Axle Load or CESAL (Frans & Nasjono, 2023). Where the VDF value of each type of commercial vehicle in the areas of Bali, Nusa Tenggara, Maluku and Papua is stated in Table 4 below.

Table 4. VDF Values for Each Type of Commercial Vehicle

Vehicle Type	Bali, Nusa Tenggara, Maluku and Papua			
	Actual Load		Normal	
	VDF 4	VDF 5	VDF 4	VDF 5
5A	1.0	1.0	1.0	1.0
6A	0.55	0.50	0.55	0.50
6B	3.00	4.00	2.50	3.00
7AI	-	-	-	-
7A2	4.90	9.70	3.90	6.00
7BI	-	-	-	-
7B2	-	-	-	-
7CI	14.00	11.90	10.20	8.00
7C2A	-	-	-	-
7C2B	-	-	-	-
7C3	-	-	-	-

Source: Highways 2017

Cumulative Standard Axle Load (CESA)

Cumulative Equivalent Single Axle Load (CESAL) is the sum of the design traffic axle loads on the design lane during the design life (Thasyara Nurhijriyah et al., 2024). The cumulative standard axle load is expressed in equation 2.3, and the CESA calculation can be seen in Table 5 below.

Table 5. Cumulative Estimates of CESA4 & CESA5 Traffic Load

Vehicle Type	LHR (2 Way) 2044	VDF4 factual	VDF 4 Normal	VDF 5 factual	VDF 5 Normal	ESA4	ESAS
1	2	3	4	5	6	7	8
Passenger cars and other light vehicles	33358.7	-	-	-	-	-	-
5A	6.2	-	-	-	-	-	-
5B	4.1	1	1	1	1	14879,8043	14879,8043
6A	17.1	0.55	0.55	0.5	0.5	33881,3144	30801,1949
6B	39.1	3	2.5	4	3	353395,352	424074,422
8	280.1	-	-	-	-	-	-
		Number of ESA				402156.47	469755,421

Source: 2024 Calculation Results

It is known:

1. Traffic growth rate (i) = 3.50%

   = 0.035
2. R (2024 – 2044) = 20.07
3. LHRT Data = LHRT 2044
4. Lane Distribution Factor (DD) = 100%

   = 1
5. Directional Distribution Factor = 0.50
6. VDF = (Table 4)

Formula used:

$$\text{ESATH-1} = (\sum LHR_{JK} \times VDF_{JK}) \times 365 \times DD \times DL \times R$$

Discussion :

$$\text{ESA4 (5b)}_{(2024-2044)} = (4{,}1 \times 1) \times 365 \times 1 \times 0{,}50 \times 20{,}07$$

$$= 14879.8043$$

$$\text{ESA5 (6a) (2024 – 2044)} = (10{,}7 \times 0{,}5) \times 365 \times 1 \times 0{,}50 \times 20{,}07$$

$$= 30801.1949$$

The total value of CESA4 is 4,021,566.47, whereas CESA5 is 469,755.421. Where CESA is segmented into CESA4, utilised for identifying pavement type, and CESA5, employed for ascertaining the thickness of the flexible pavement layer according to the provided design chart.

Determining the Type of Pavement

With a CESA4 value of 4021566.47, the pavement structure that can be considered can be determined, including those shown in Table 6 below.

Table 6. Selection of Pavement Type

Pavement Structure	Design Chart	ESA (million) in 20 years (power 4 unless otherwise specified)				
		0-0.5	0.1-4	>4-10	>10-30	>30-200
Rigid pavement with heavy traffic (on soil with CBR≥ 2.5%)	4	-	-	2	2	2
Rigid pavement with low traffic (rural and urban areas)	4A	-	1.2	-	-	-
Modified AC WC or modified SMA With CTB (ESA to the power of 5)	3	-	-	-	2	2
AC with CTB (ESA Power 5)	3	-	-	-	2	2
AC thickness ≥ 100 mm with granular base layer (ESA power 5)	3B	-	1.2	1.2	2	2
Thin AC or HRS on granular base layer (ESA power 5)	3A	-	1.2	-	-	-
Burda or burlu with LFA Class A or native rock	5	3	3	-	-	-
Soil Cement Foundation Layer	6	1	1	-	-	-
Unsealed pavement (can, gravel road)	7	1	-	-	-	-

Source: Highways 2017

With a CESA4 value of 4021566.47, there are 5 pavement structures that can be considered, namely design chart 4A, design chart 3B, design chart 3A, design chart 5 and design chart 6.

Thickness of Pavement Layer

With design chart 3A and a CESA5 value of 469755.421, the selection of pavement layer thickness can be seen in Tables 4.16 and 4.17 below.

Table 7. Design Chart - 3A Flexible Pavement Design with HRS1

Cumulative 20-year axle load on design lane (106CECAS)	**FF1<0.5**	**0.5≤FF2≤4.0**
Surface Type	**HRS or Macadam Penetration**	**HRS**
Pavement Structure	Layer Thickness (mm)	
HRS WC	50	30
HRS Base	-	35
LFA Class A	150	250
LFA Class A or LFA Class B or Natural gravel or stabilized layer with CBR > 10%3	150	125

Source: Highways 2017

Flexible pavement with HRS is an asphalt mixture that uses aggregate with gap gradation, in addition to the CESA value below 2 million also because HRS or LATASTON has high durability and flexibility because it has a high asphalt content, but the stability of this HRS is low (Kurniawan et al., 2017). With the provisions of the type of surface and layer thickness as shown in Figure 4.1 below.

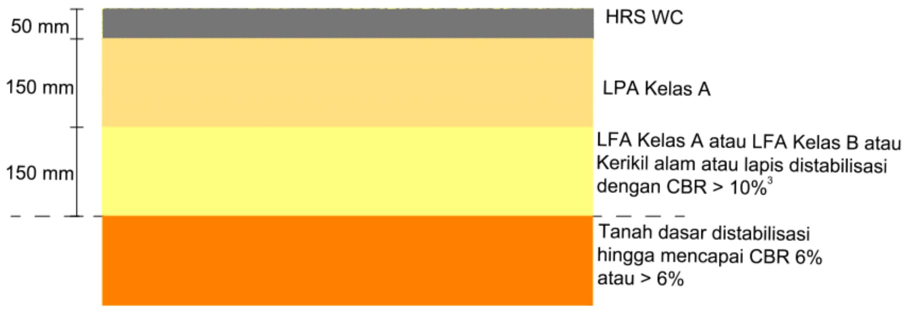

Figure 2. Flexible Pavement Thickness Design with HRS1

Because passenger cars, light vehicles and non-motorized vehicles passing through Jalan Darul Hikmah are very dense or very dominant than vehicles in class 5a – 6b, then Design Chart – 3B Flexible Pavement Design – Asphalt With Granular Foundation Layer can be used as an alternative or option to choose the type of flexible pavement on Jalan Daul Hikmah (Isradi et al., 2023). Where Design Chart – 3B can be seen in Table 4.17 below.

Table 8. Design Chart - 3B Flexible Pavement Design - Asphalt with Granular Base Course

	PAVEMENT STRUCTURE							
	FFF1	**FFF2**	**FFF3**	**FFF4**	**FFF5**	**FFF6**	**FFF7**	**FFF8**
	Selected solution					**See note 2**		
Cumulative 20-year axle load on design lane (106 ESA5	< 2	≥2-7	>7-10	>10-20	>20-30	>30-50	>50-100	>100-200
PAVEMENT LAYER THICKNESS								
Air Conditioning Toilet	40	40	40	40	40	40	40	40
AC BC	60	60	60	60	60	60	60	60
AC Base	0	80	105	145	160	180	210	245
LFA Class A	400	300	300	300	300	300	300	300
Notes	1		2			3		

Source: Highways 2017

FFF1 is chosen because the CESA5 value is below 2 million with a value of 469755.421. With the note that what must be prioritized in the selection of pavement structure is FFF1 or FFF2 rather than the FF1 and FF2 solutions (Design Chart - 3A). If HRS has the potential to experience rutting, FFF1 and FFF2 can be used. With the provisions of the type of surface and layer thickness as shown in Figure 4.2 below.

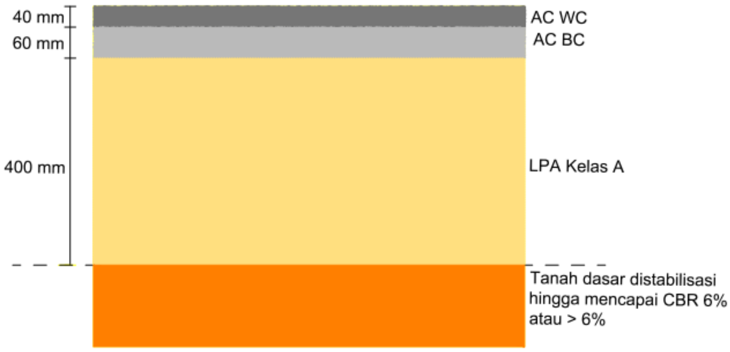

Figure 3. Flexible Pavement Thickness Design - Asphalt with Granular Base Layer
(Source: Bina Marga 2017)

CONCLUSION

Based on the analysis results, several conclusions were obtained, including the densest traffic with 16,366 vehicles on Thursday, because it is influenced by the large number of residents and Jalan Terong Tawah is an alternative road from the Labu Api area, West Lombok to the Mataram area. Because Thursday has the busiest number of vehicles, the LHRT value is calculated from Thursday's data, with a traffic growth value at the end of the 20-year plan life (2044) of 33,705,232 vehicles. The thickness of the pavement layer using the 2017 Road Pavement Design Manual (Bina Marga) method on Jalan Darul Hikmah, Terong Tawah, obtained a highly recommended option for determining the thickness of the pavement layer, namely by using Flexible pavement thickness - Asphalt with a granular foundation layer AC – WC = 4 cm, AC – BC, = 6 cm, AC Base, LFA Class A = 40 cm. The difference in flexible pavement thickness on Jalan Darul Hikmah, Terong Tawah, on the surface layer or surface course with a thickness of 7 cm, which has been overlaid. While in the results of this study the upper surface layer of the Asphalt surface course with a 10 cm granular foundation layer.

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