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Flexible Pavement Design Analysis Using Bina Marga 2017 Method for the Road Section from Banjang-Pulau Nyiur to Batu Mandi, Hulu Sungai Utara

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ABSTRACT

The Banjang, Pulau Nyiur, Batu Mandi road is one of the provincial roads in South Kalimantan located in the Hulu Sungai Utara. This road falls under the jurisdiction of the South Kalimantan Provincial Government and has a total length of 12.5 km. Some parts of this road still lack asphalt pavement, and there are plans for future improvements to enhance driving comfort and facilitate inter-regional transportation. Therefore, there is a need for appropriate pavement thickness planning that aligns with the field conditions and regulations. This study employs the flexible pavement thickness planning method according to the Bina Marga 2017 guidelines, with a design life of 20 years and a traffic growth rate of 3.5%. The surface thickness planning utilizes Asphalt Concrete (AC) with a wearing course (AC WC), and an AC Base layer with LPA Class A aggregate gradation. The results of this study indicate that the calculated flexible pavement thickness using the Bina Marga 2017 method is 58 cm, comprising a 10 cm AC WC layer, an 18 cm AC Base layer, and a 30 cm LPA Class A aggregate layer

INTRODUCTION

In Indonesia, there is a classification of road statuses, which include national roads, provincial roads, district roads, city roads, and village roads. Provincial roads are collector roads within the primary road network system that connect the provincial capital to the district/city capital or between district/city capitals, as well as strategic provincial roads. The segments of provincial roads are designated by the Governor through a Governor's Decree (SK Gubernur). Provincial roads can be identified by road markings that are only white (without yellow). Provincial road markings in white take the form of longitudinal lines, both dashed and continuous. Generally, provincial roads are fairly wide, and in some areas, the width of provincial roads is the same as that of national roads.

South Kalimantan, as one of the provinces, covers an area of 38,744 square kilometres. This province has jurisdiction over 756.12 kilometres of provincial roads and 780.84 kilometres of strategic provincial roads spread across 13 districts/cities, according to the Governor's Decision Number 188.44/KUM/2018. With the extensive road network managed by the Provincial Government, new road construction is undertaken every year to facilitate smooth traffic flow for the community. These new roads are designed per the surrounding environmental conditions and consider the local traffic patterns to ensure seamless traffic movement.

The smooth flow of traffic has become a crucial necessity for the progress of a country, Indonesia being no exception. Indonesia is a country that has experienced rapid development in recent years. Each day witnesses high levels of community movement, underscoring the need for infrastructure that can support the smooth mobility of its people, mainly through well-equipped road networks. The quality and capacity of road segments directly correlate with the fluidity of community mobility, making it easier to traverse distances. As societal movement accelerates, the region's level of development and economic growth correspondingly expands.

The fundamental requirement for a road is the presence of an adequate road pavement layer. As commonly understood, the natural soil cannot directly bear traffic loads without undergoing deformation. A road pavement is a structure between natural soil and the vehicle's wheels. Its function is to distribute traffic loads to the underlying soil without exceeding the strength of the soil itself. This pavement is expected to ensure the safety of traffic movement for a considerable duration, with minimal maintenance.

With the current growth in traffic volume, in line with the era of sustainable development, the need for road capacity naturally increases. Considering the general condition of existing roads, a portion of these roads is expected to be inadequate for meeting future traffic demands due to factors such as the escalating traffic load, diminishing structural value of the pavement, and inadequate road capacity (including road width, pavement width, and road shoulders). To address this, it is imperative to implement an integrated road pavement planning system through projects to enhance existing roads and construct new ones. To achieve this goal, particularly in selecting pavement construction that is efficiently aligned with the traffic demands, Bina Marga has established a guideline for designing pavement thickness, specifically for provincial roads. This ensures a unified criterion in the selection of planning criteria.

The Banjang - Pulau Nyiur - Batu Mandi road is one of the provincial roads in South Kalimantan located in the Hulu Sungai Utara. This road falls under the jurisdiction of the South Kalimantan Provincial Government, with a total length of 12.5 km. Some parts of this road still lack asphalt pavement, and there are plans for future improvements to enhance driving comfort and facilitate inter-regional transportation.

METHODS

This research was conducted on a provincial road along the Banjang - Pulau Nyiur - Batu Mandi route. The study was conducted over two months, from March 01, 2022, to May 01, 2022. The subject of this research is the thickness of flexible pavement on the Banjang - Pulau Nyiur - Batu Mandi road. The research process comprises preliminary stages, data collection, data processing, analysis, and conclusion and recommendation.

RESULTS AND DISCUSSION

Planning

This research was conducted on a provincial road along the Banjang - Pulau Nyiur - Batu Mandi route, with a road length of 2,228 meters and a width of 3.5 meters.

Figure 1. Segment of the Banjang - Pulau Nyiur - Batu Mandi Road

The road planning for the Banjang - Pulau Nyiur - Batu Mandi road segment employs the Bina Marga 2017 method. The design life utilized is 20 years. This road is classified as a provincial road, with a single-lane two-way configuration and no median separator (2/2 Undivided) that connects different districts.

Table 1. Subgrade CBR Data

Point	CBR Value (%)			Average CBR Value (%)
	Layer 1	Layer 2	Layer 3	
1	32	18	22	24
2	12,6	6	14,4	11
3	6,3	13	21	13,4
4	6,2	8,2	11	8,5

Design Thickness Planning of Flexible Pavement according to Bina Marga 2017

The Design Life (DL) is the number of years counted from the start of the road's opening until substantial repair is needed or when applying a new surface layer is deemed necessary. In the initial stage of pavement design, determining the design life of the road is crucial. Based on Table 2. for flexible pavements with asphalt layer and granular layer components, a design life of 20 years is used.

Table 2. Determination of New Road Pavement Design Life (DL)

<table>
<tr><th>Pavement Type</th><th>Pavement Elements</th><th>Design Life (years)</th></tr>
<tr><td rowspan="4">Flexible Pavement</td><td>Asphalt layer and granular layer</td><td>20</td></tr>
<tr><td>Road Foundation</td><td rowspan="4">40</td></tr>
<tr><td>All pavements for areas where re-paving (overlay) is not feasible, such as urban roads, underpasses, bridges, and tunnels.</td></tr>
<tr><td>Cement Treated Based (CTB)</td></tr>
<tr><td>Rigid Pavement</td><td>The upper foundation layer, lower foundation layer, concrete cement layer, and road foundation.</td></tr>
<tr><td>Unsurfaced Road</td><td>All elements (including road foundation)</td><td>Minimum 10</td></tr>
</table>

The traffic growth rate factor (i) is 3.50% for the Kalimantan region, as per Table 3. Traffic growth over the design life is influenced, among other factors, by economic and social analyses of the area, leading to an annual increase in the number of vehicles.

Table 3. Determination of Traffic Growth Rate Factor (i) (%)

	Java	**Sumatra**	**Borneo**	**Indonesian Average**
Arterial 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

The design lane is one of the traffic lanes within a road section that accommodates the heaviest commercial vehicle traffic (trucks and buses). The traffic load on the design lane is expressed in terms of the cumulative standard axle load (ESA) while accounting for the directional distribution factor (DD) and the commercial vehicle lane distribution factor (DL). For two-way roads, the directional distribution factor (DD) is typically taken as 0.50, except in locations where the volume of commercial vehicles tends to be higher in a specific direction.

The lane distribution factor adjusts the cumulative load (ESA) on roads with two or more lanes in one direction. Although most commercial vehicles will use the outer lane on such roads, some will use the inner lanes. The lane distribution factor obtains a value of 1 because there is only one lane in each direction.

The next step is determining the Equivalent Load / Vehicle Damage Factor (VDF). The VDF value used is the Kalimantan region's actual load based on the field's natural conditions. The Equivalent Load Factor or Vehicle Damage Factor is a factor that represents the comparison of the pavement damage caused by a specific vehicle track. In pavement design, the equivalent load factor is a conversion factor from traffic load to the standard load (ESA).

Table 4. Determination of VDF Values for Each Type of Commercial Vehicle

Transportation type	Sumatera				Java				Borneo			
	Actual Load		Normal		Actual Load		Normal		Actual Load		Normal	
	VDF 4	VDF 5	VDF 4	VDF 5	VDF 4	VDF 5	VDF 4	VDF 5	VDF 4	VDF 5	VDF 4	VDF 5
5B	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	**1,0**	1,0	1,0
6A	0,55	0,5	0,55	0,5	0,55	0,5	0,55	0,5	0,55	**0,5**	0,55	0,5
6B	4,5	7,4	3,4	4,6	5,3	9,2	4,0	5,1	4,8	**8,5**	3,4	4,7
7A1	10,1	18,4	5,4	7,4	8,2	14,4	4,7	6,4	9,9	**18,3**	4,1	5,3
7A2	10,5	20,0	4,3	5,6	10,2	19,0	4,3	5,6	9,6	**17,7**	4,2	5,4
7B1	-	-	-	-	11,8	18,2	9,4	13,0	-	-	-	-
7B2	-	-	-	-	13,7	21,8	12,6	17,8	-	-	-	-
7C1	15,9	29,5	7,0	9,6	11,0	19,8	7,4	9,7	11,7	**20,4**	7,0	10,2
7C2A	19,8	39,0	6,1	8,1	17,7	33,0	7,6	10,2	8,2	**14,7**	4,0	5,2
7C2B	20,7	42,8	6,1	8,0	13,4	24,2	6,5	8,5	-	-	-	-
7C3	24,5	51,7	6,4	8,0	19,1	34,4	6,1	7,7	13,5	**22,9**	9,8	15,0

Based on the traffic survey data of vehicle types passing through, as shown in Table 4, the relevant vehicle types used in the calculations are large buses, light 2-axle trucks (4 wheels), heavy 2-axle trucks (6 wheels), single-axle 3-axle trucks, and 4-axle trucks (trailers/containers). The VDF values for each vehicle type can be found in Table 4.7: for vehicle type 5B, VDF value 5 = 1.00; for vehicle type 6A, VDF value 5 = 0.5; for vehicle type 6B, VDF value 5 = 8.5; for vehicle type 7A1, VDF value 5 = 18; and for vehicle type 7C1, VDF value 5 = 20.4.

The axle loads of passenger vehicles and light to medium vehicles are relatively small, thus posing no potential for causing structural damage to the pavement. Only commercial vehicles with six or more wheels need to be considered in the analysis. The detailed calculations are provided in the following Table 5.

Table 5. Calculation of ESA5 Value

Transportation type	Average Daily Traffic (Two Directions) 2019	LHR 2022	VDF 5 factual	ESA5 ('22-'42)
Passenger cars and other light vehicles should be accounted for.	-	-	-	-
5B	5	6	1	$2,1x10^4$
6A	76	88	0,5	$1,6x10^5$
6B	831	966	8,5	$3,0x10^7$
7A1	76	88	18,3	$5,9x10^6$
7C1	16	19	20,4	$1,4x10^6$
			Total ESA5	$3,8x10^7$

The pavement type selection will vary based on traffic volume, design life, and road foundation conditions. The limits in Table 6. are not absolute; planners must consider the lowest cost over the design life, limitations, and implementation feasibility. The choice of design alternatives based on this manual should be based on the lowest discounted lifecycle cost.

Table 6. Selection of Pavement Types

Pavement Structure	**Design Chart**	**ESA (Million) in 20 years (Raised to the power of 4 unless otherwise specified)**				
		0-0,5	**1-4**	**>4-10**	**>10-30**	**>30-200**
Rigid pavement with heavy traffic (above ground with CBR≥2.5%)	4	-	-	2	2	2
Rigid pavement with light traffic (rural and urban areas)	4A	-	1,2	-	-	-
Modified AC WC or modified SMA with CTB (ESA raised to the power of 5)	3	-	-	-	2	2
Asphalt Concrete (AC) with CTB (ESA raised to the power of 5)	3	-	-	-	2	2
Thick AC ≥ 100 mm with granular foundation layer (ESA raised to the power of 5)	3B	-	-	**1,2**	2	2
Thin AC or HRS over granular foundation layer	3A	-	1,2	-	-	-
Burda or Burtu with LPA Class A or natural rock	5	3	3	-	-	-
Soil Cement Foundation Layer	6	1	1	-	-	-
Unsurfaced Pavement (Japat, gravel road)	7	1	-	-	-	-

Based on the ESA5 value of 3.2×10^7, it falls within the range of ESA 4-10 million; thus, the design will use chart 3B.

Based on the calculation of the ESA5 value, a value of $3.8 \times 10^7 = 38 \times 10^6$ is obtained. From this value, the thickness of the flexible pavement can be determined according to Table 7.

Table 7. Determination of Flexible Pavement Design with Asphalt Concrete (AC)

	PAVEMENT STRUCTURE							
	FFF1	**FFF2**	**FFF3**	**FFF4**	**FFF5**	**FFF6**	**FFF7**	**FFF8**
Selected Solution								
20-year cumulative axle load on the design lane (10^6ESA5)	< 2	≥ 2-7	> 7-10	>10-20	>20-30	>30-50	>50-100	>100-200
Pavement Layer Thickness (mm)								
AC WC	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

The conclusion drawn from the table is that the thickness of the AC-WC pavement layer is 40 mm = 4 cm, the AC-BC layer is 60 mm = 6 cm, the AC-Base layer is 180 mm = 18 cm, and LPA Class A is 300 mm = 30 cm, based on table 4.8. However, in the asphalt pavement design, only AC WC is used with a thickness of 10 cm.

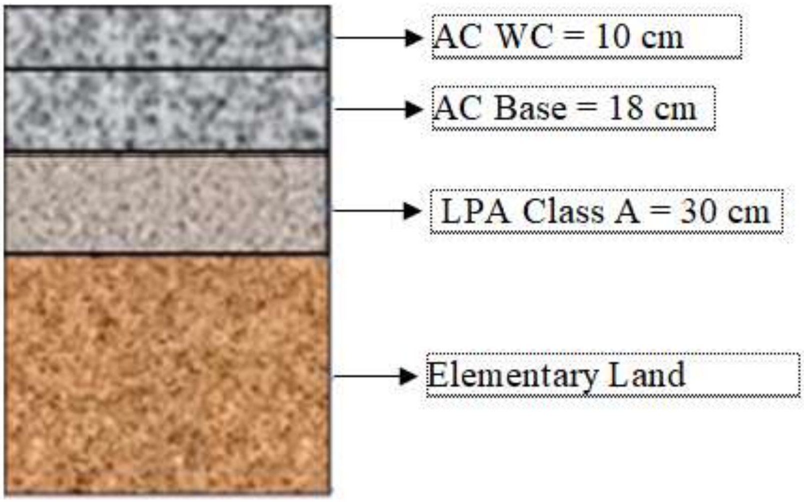

Figure 2. Result of Flexible Pavement Design Thickness using Bina Marga 2017 Method

Conclusion

The conclusion that can be drawn is that the thickness of the flexible pavement layer in the design using the Bina Marga 2017 method is 58 cm, with details including AC-WC at 100 mm = 10 cm, AC-Base at 180 cm = 18 cm, and LPA Class A at 300 mm = 30 cm.

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