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Rigid Pavement Thickness Planning Using The Aashto 1993 Method On The Road Section Of Danau Rawah Village, Kapuas District, Central Kalimantan

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Abstract

The road section of Danau Rawah Village, Timah District, KapuasRegency, has a length of 1 km with a road width of 3 meters. This section is a localroad (rural collector) with 1 lane and 2 directions without a separator median, connecting different subdistricts. The condition of this road is that it is still unpaved and graveled. Therefore, there is a need to plan the appropriate road pavement thickness according to field conditions and in compliance with regulations.

This research plans the rigid pavement thickness using the AASHTO 1993 method with a planned lifespan of 20 years. The calculated values include the concrete slab thickness, the thickness of the surface pavement, and soil improvement based on the subgrade's CBR data. The LHR data is obtained through direct surveys as the analytical material to obtain the planned traffic design values.

The results obtained in the study of rigid pavement thickness planning using the AASHTO 1993 method for a planned lifespan of 20 years are as follows: the thickness of the concrete slab for the rigid pavement is 20 cm, the thickness of the upper pavement layer is 20 cm, and the process or improvement of the subgrade is 10 cm.

Keywords: Rigid Pavement, AASHTO 1993, Danau Rawah Village

1. INTRODUCTION

The area of Kapuas Regency is as vast as 14,999 square kilometers or 1,499,900 hectares (9.77 percent of the total area of Central Kalimantan Province). It is divided into two major regions: the tidal zone (mostly in the southern part), which is a potential area for food crop agriculture, and the non-tidal area (mostly in the northern part), which is the potential land for smallholder rubber plantations and large private plantations (BPS, 2021)

The population density of Kapuas Regency was only 27 people/km^2 in 2020. The population composition and distribution are uneven, and the condition of the roads is also affected by the environmental conditions of the marshy area and soft soil with low soil-bearing capacity. Therefore, special treatment is required to strengthen the soil-bearing capacity in the implementation of road pavement.

The Danau Rawah area, which is located far from the current sub-district, is still partially unattended because the road to the village is approximately 27 kilometers away and is the only main road connecting the village road to the Palangkaraya - South Barito Regency crossroad. The pavement that will be used is rigid pavement using the AASHTO 1993 method with a planned service life (UR) of 20 years to accommodate the swampy environmental conditions and maintenance time, which will certainly be relatively longer compared to the flexible pavement, in order for the research objective to determine the design thickness of rigid pavement using the AASHTO 1993 method in the Road Improvement Project, Danau Rawah Village, Mantangai District, Kapuas Regency, based on a planned road life of 20 years, to be achieved and executed successfully.

2. RESEARCH METHOD

2.1 Research Location

The location in this study is located along the Danau Rawah Village road using the AASHTO 1993 method in Kapuas Regency, Timpah District, as shown in Figure 1 below:

Figure 1. Research Location using the AASHTO 1993 method

2.1 Research Period

This research was conducted for a duration of 2 months, starting from July 1, 2023, to August 31, 2023

2.2 Research Object

The object of this research is the Danau Rawah Village Road section in Kapuas Regency, Timpah District.

2.3 Research Stages

The subject of this research is the Desa Danau Rawah Village Road section in Kapuas Regency, Timpah District.

2.4 Introduction Stage

The initial step in this planning process is a literature review of previous research or planning to gain an understanding of the planning steps and the required data for the design.

2.5 Data Collection Stage

The required data includes Primary Data, which consists of traffic data that will be directly counted in the field according to the road sections designed for improvement, and Secondary Data, which comprises supporting data needed for data analysis. Once the primary and secondary data have been fully collected, the next step is data processing and analysis with a 20-year planning horizon.

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2.6 Conclusion and Recommendations Stage

Road pavement dimensions at the planning location.

3. RESULTS AND DISCUSSION

3.1 Overview of Planning

Figure 2. Condition of the Danau Rawah Village - Timpah Road Section, Kapuas District

Based on the field Average Daily Traffic (ADT) survey results, the data obtained are as follows in Table 1 below:

Table 1. Average Daily Traffic (ADT) Data on the Danau Rawah Village - Timpah Road Section

No	Code	Vehicle Type	Quantity
1	1	Motorbike	280
2	2	Sedan / Jeep	11
3	3	Mini Van Bus	38
4	4	Pick Up / Delivery Vehicle	23
5	5A	MPU/ Small Bus	1
6	5B	Large Bus	-
7	6A	Light 2-Axle Truck (4 Wheels)	4
8	6B	Heavy 2-Axle Truck (6 Wheels)	-
9	7A.1	3-Axle Truck (single)	-

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10	7A.2	3-Axle Truck (tandem)	-
11	7B	Articulated Truck	-
12	7C1	4-Axle Truck (Trailer/ Container)	-
13	7C2A	5-Axle Tandem Truck (Trailer/ Container)	-
14	7C2B	5-Axle Triple Truck (Trailer/ Container)	-
15	7C3	6-Axle Truck	-
16	8	Non-Motorized Vehicles (Rickshaws, Bicycles, Carts)	38

Source: Field Survey

3.2 Secondary Data

Based on the data obtained, the CBR data is known to be 6%, with a direction distribution factor (D_D) = 0.3 - 0.7; lane distribution (D_L) and Vehicle Damage Factor (VDF) in Table 2 below:

Table 2. Lane Distribution Factors

Number of lanes in each direction	D_L (%)
1	100
2	80-100
3	60-80
4	50-75

Source: DPU 2005

The planned lifespan of rigid pavement can be seen in Table 3:

Table 3. The Lifespan of Road Pavement Plan

Pavement Type	Pavement Elements	Planned Service Life (years)
	Asphalt layer and aggregate layer.	20
	Road foundation	

Flexible Pavement	All pavements for areas where resurfacing is impossible (overlay), such as urban roads, underpasses, bridges, and tunnels.	40
	Cement Treated Based (CTB)	
Rigid Pavement	Lapis fondasi atas, lapis fondasi bawah, lapis beton semen, danfondasi jalan.	
Road without a surface cover	All elements (including road foundation)	Minimum 10

Source: MDP, 2017

The planned lifespan for rigid pavement is 20 years. The reliability factor can be seen in the following.

Table 4. Recommended Reliability Factor (R)

Road Classification	**Reliability R (%)**	
	Urban	**Rural**
Toll Road	85 – 99.9	80 – 99.9
Arterial	80 – 99	75 – 95
Collector	80 – 95	75 – 95
Local	50 – 80	50 – 80

Source: DPU, 2005

3.2 Data Analysis

Based on the table and description above, the following data is obtained: The value of the direction distribution factor is (D_D) = 0.5 (average value taken), and the distribution factor value for one lane is (D_L) = 100%. Based on the data above, traffic design calculations (ESAL) are obtained as shown in Table 5 below

Table 5. Traffic Design (ESAL)

No	Kode	Jenis Kendaraan	Jumlah	VDF	DD	DL	ESAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) = (4)*(5)*(6)*(7)
1	1	Sepeda Motor	280	0	0,5	1	-
2	2	Sedan / Jeep	11	0,00005	0,5	1	0,100
3	3	Van Mini Bus	38	0,2174	0,5	1	1.508
4	4	Pick Up / Mobil Hantaran	23	0,2174	0,5	1	913
5	5A	MPU/ Bus Kecil	1	0,2174	0,5	1	40
6	5B	Bus Besar	-	0,3006	0,5	1	-
7	6A	Truck 2 Sumbu Ringan (4 Roda)	4	2,4159	0,5	1	1.764
		Total	357				4.224

Source: Calculation Results

Based on Table 5, the traffic design calculation results in an ESAL (W_{18}) value of 4.224, categorizing the road as having low traffic.

The type and class of road are classified as a Rural Collector, with a reliability factor (R) of 80% for the Kalimantan region (Table 5), thus, the standard normal deviation value (Z_R) obtained is -0.841. Meanwhile, the standard deviation value (So) ranges from 0.3 to 0.4, and So = 0.35 is taken.

The serviceability value is obtained with the following data:

The initial serviceability index value for rigid pavement is (po) = 4.5 (AASHTO 1993 regulations).

The serviceability index value for a road with low traffic (pt) = 2.0 (AASHTO 1993 regulations)

Total loss in serviceability $\Delta PSI = po - pt = 4.5 - 2.0 = 2.5$

Calculation of base soil reaction modulus (k) is as follows:

1. Design CBR is a minimum of 6% (based on AASHTO 1993)
2. of stiffness modulus (M_R)

   $M_R = 1500 \times CBR = 1500 \times 6 = 9000\ pci$

   $k = \frac{M_R}{19.4} = \frac{9000}{19.4} = 464\ pci$

3. Calculation of concrete elastic modulus (E_C) as follows:
   a. $f'_c = 375\ kg/cm^2$ = 5,333 psi, with (1 kg/cm² = 14,22 psi)
   b. $E_c = 57.000\sqrt{f'_c} = 57.000\sqrt{5.333}$

      $= 4{,}162{,}366\ psi = 292{,}712\ kg/cm^2$

      Or rounded to 4,163,000 psi or 292,800 kg/cm²

4. Flexural strength test with a requirement of $(S'_C) = 45\ kg/cm^2 = 640\ psi$

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5. Determination of the load transfer coefficient (J) = 2,5 (Tabel .6)

Table 6. Load Transfer Coefficient (J)

Shoulder	Asphalt		Tied PCC	
Load transfer device	Yes	No	Yes	No
Pavement type				
1. *Plain jointed & jointed reinforced*	3.2	3.8 – 4.4	2.5 – 3.1	3.6 – 4.2
2. CRCP	2.9 – 3.2	N/A	2.3 – 2.9	N/A

Source: DPU, 2005

6. Calculation of drainage coefficient (C_d) based on drainage quality in

Table 7 Drainage Coefficients (C_d)

Quality of Drainage	Percentage of Pavement Exposed to Water			
	<1%	1-5%	5-25%	>25%
Excellent	1.4 - 1.35	1.35 - 1.3	1.3 - 1.2	1.2
Good	1.35 - 1.25	1.25 - 1.15	1.15 - 1.0	1.0
Fair	1.25 - 1.15	1.15 - 1.05	1.0 - 0.80	0.80
Poor	1.15 - 1.05	1.05 - 0.80	0.80 - 0.60	0.60
Very Poor	1.05 - 0.95	0.95 - 0.75	0.75 - 0.40	0.40

Source: DPU, 2005

With the data:

1. Average rainfall per day (Thours) = 2 hours per day (Assumption for the planning location)
2. Average number of rainy days per year (Thari) = 40% x 365 = 146 rainy days per year (Assumption for the planning location)
3. Rainwater infiltration factor into the road foundation (WL) = 10% (Assumption for the planning location)
4. The calculation of the percentage of pavement structure exposed to water in 1 year is as follows:

$$P_{heff} = \frac{T_{jam}}{24} \times \frac{T_{hari}}{365} \times W_L \times 100$$

$$P_{heff} = \frac{1}{24} \times \frac{148}{365} \times 10\% \times 100 = 0.33\% < 1\%,$$

dengan kualitas drainase sangat bagus, maka diperoleh Cd = 1,20

Calculation of pavement thickness (D) using the following equation

$$Log\ ESAL = Z_R S_o + 7.35\ Log\ (D+1) - 0{,}06 + \frac{\log\left[\frac{\Delta PSI}{4.5-1.5}\right]}{1 + \frac{1.624 \times 10^7}{(D+1)^{8.46}}} + (4.22 - 0.32p_t) \times \log\left[\frac{S'_c C_d (D^{0.75} - 1.132)}{215.63 J \left(D^{0.75} - \frac{18.42}{(E_c/k)^{0.25}}\right)}\right]$$

Based on trial and error, the appropriate pavement thickness for the ESAL value is 3.455 inches or 8.776 cm, which can be rounded to 9 cm.

4. RESULTS AND DİSCUSSİON

Based on the data analysis, the results obtained are shown in Table 8 below:

Table 8. Data Analysis Results

Calculation of Pavement Thickness						
Planned Life Span	:	20	Years			
ESAL (W18)	:	4224				
CBR	:	6	%			
Subgrade Reaction Modulus	:	463.92	pci	=	12.76	kg/cm3
Base (k)	:	4200000	psi		292800	kg/cm2
Concrete Elastic Modulus	:	639.9	psi		45	kg/cm2
(EC)	:	2.5				
Flexural Strength (Sc')	:	1.2				
Load Transfer Coefficient (J)	:	4.5				
Drainage Coefficient (Cd)	:	2				

Serviceability (po)	:	80	%			
Serviceability Loss (pt)	:	-0.841				
Reliability (R)	:	0.35				
Normal Standard Deviation	:	3.45	in	=	8.7757	cm
(ZR)	:	6.169		<	6.169	

From the equation check, the plate thickness obtained (Dmin) is 9 cm (rounded result), with an equivalent ESAL (W18) capacity of 1,475,706.53. The plate thickness calculation using the AASHTO 1993 method results in a minimum value of 9 cm because, during the Average Daily Traffic (ADT) survey, traffic was relatively low. In this planning, a concrete pavement thickness of 20 cm was adopted to meet the standards in using the AASHTO 1993 method. With a subgrade CBR (California Bearing Ratio) >6%, so no pavement is needed; the thickness of the upper pavement layer is 6 inches, which is rounded to 20 cm, with a subgrade improvement of 10 cm because it is possible that along a 1 km road, not all of the subgrade has a CBR of 6%.

From the calculations above, the conclusion drawn in this research is the design of a rigid pavement with a planned lifespan of 20 years using the AASHTO 1993 method, using the following data:

a. ESAL (W18) = 4,224
b. Soil modulus of elasticity = 12.76 kg/cm^3
c. Concrete modulus of elasticity = 292,800 kg/cm^2
d. Concrete flexural strength = 45 kg/cm^2
e. Load transfer coefficient = 2.5
f. Drainage coefficient = 1.2
g. Terminal serviceability index = 2.5
h. Reliability = 80%
i. Normal standard deviation = -0.841
j. Standard deviation = 0.35

Concrete Plate Thickness		20 cm
Upper Hardening Layer		20 cm
Foundation Soil		10 cm (CBR 6%)

Figure 3. The Thickness of Rigid Pavement Structure

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