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TECHNICAL ANALYSIS OF RIGID PAVEMENT AND FLEXIBLE PAVEMENT CALCULATIONS ON TEUKU UMAR ROAD – RAJAWALI ROAD

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Abstract

Road development in Sampang Regency is carried out based on the Vision and Mission of the 2019-2024 RPJMD, as stated in Mission point 3 Infrastructure: "Improving Quality and Sustainable Infrastructure Development." In 2023, the Sampang Regency Public Works and Spatial Planning Office reported that road stability was at 46.54% of the total length of 754.12 km of district roads. This research on the Teuku Umar Road - Rajawali Road Preservation project aims to analyze the calculation of rigid pavement construction thickness planning for a design life of 20 years, and flexible pavement construction using the Road Pavement Design Manual No. 02/M/BM/2017 method. The analysis of calculations for both rigid and flexible pavements uses the Road Pavement Design Manual Method No. 02/M/BM/2017 for a design life of 20 years. The results of this research indicate that the rigid pavement design includes 200 mm thick concrete, 100 mm skinny concrete, and 150 mm class A aggregate LPA. For the flexible pavement, the design includes 40 mm AC-WC Laston, 60 mm AC-BC Laston, and 400 mm class A aggregate LPA.

Keywords: *Rigid Pavement, Flexible Pavement, Pavement Design*

1. INTRODUCTION

Roads are land transportation infrastructure that includes all parts of the road including complementary buildings and equipment intended for traffic above the ground, below the ground, and above the water surface, except railways, lorries, and cables. Public roads are roads intended for public traffic, while special roads are roads built by agencies, business entities, individuals, or community groups for their own interests. Road parts include road benefit space, road property space, and road surveillance space as stated in the Law of the Republic of Indonesia Number 38 of 2024.

Based on Government Regulation Number 34 of 2006 concerning Roads, it is explained that the conceptual and comprehensive implementation of roads needs to see roads as a unified road network system that binds and connects centers of activity. In this connection, the primary road network system and the secondary road network system are known. In each road network system, roads are grouped according to function, status, and road class. The grouping of roads based on status gives the Government the authority to organize roads that have national services and local governments to organize roads in their areas in accordance with the principles of regional autonomy.

Data from the Ministry of PUPR (2023 Semester II) road stability in good condition in Indonesia amounted to 94.18% of the total length of the National Road 47,603.49 Km. The achievement of this percentage is certainly supported by many factors, including

infrastructure development factors in regions throughout Indonesia. The stability of provincial roads in East Java based on data from the East Java Provincial Bina Marga Public Works Office in 2023 amounted to 89.09% of the total length of 1421 km. Sampang Regency is one of four regencies located on Madura Island, East Java (Bangkalan, Pamekasan and Sumenep). The regional boundary to the north is bordered by the Java Sea, to the south is bordered by the Madura Strait, to the east is bordered by Pamekasan Regency, while to the west is bordered by Bangkalan Regency. The length of roads in 2024 based on road data from the Sampang Regency Public Works and Spatial Planning Office contained in the Regency Road Decree Number: 188.45/457.1/KEP/434.013/2023 is 754.12 Km with details of steady conditions of 44.65% and unsteady conditions of 55.35%. Infrastructure development is important in today's society. This can be seen from the rampant development of infrastructure development in various sectors, ranging from roads, telecommunications, clean water networks to energy supply systems.

The development of road infrastructure in the current era, especially road construction on district roads, is carried out based on the Vision and Mission of the 2019-2024 RPJMD leadership of the Sampang Regent and Deputy Regent of Sampang H. Slamet Junaidi - H. Abdullah Hidayat which is stated in Mission point 3 Infrastructure "Improving Quality and Sustainable Infrastructure Development". The condition of Sampang Regency roads is based on road condition data from the Sampang Regency Public Works and Spatial Planning Office in 2023, road stability is 46.54% of the total length of 754.12 Km district roads and the type of flexible pavement is more dominant at 464.25 Km. It is necessary to conduct several reviews to overcome the level of road damage decreasing (Putra, 2022).

As an implementer of public policy, the Sampang Regency Public Works and Spatial Planning Office is a technical implementing element of Regional Government affairs which has the task of carrying out Government affairs in the field of public works which includes planning, implementing and controlling services in accordance with Regional Head policies. Related to this, many public works activities have been carried out. However, not all public works activities, especially infrastructure development, can support quality and sustainable infrastructure development in Sampang Regency. Thus, to see the level of success and achievement of the objectives of the implementation program, it is necessary to carry out activities on the benefits/impacts of development implementation programs that have been implemented.

Sampang City is a medium-sized city whose population is increasing from year to year. The more population that requires the use of land transportation, the more the level of congestion and road damage, especially on Jalan Teuku Umar - Jl. Rajawali. The area is the central area of traffic movement activities such as Srimangunan Main Market and Trunojoyo Terminal located on Teuku Umar Street while Muhammad Zyn Hospital is located on Rajawali Street. The Sampang Regency Government through the Sampang Regency Public Works and Spatial Planning Office is currently in the process of planning the improvement of Teuku Umar Road - Rajawali Road along approximately 1370 meters with the consideration of facilitating traffic flow in the area.

Pavement planning is something that must be planned as well as possible so that road construction can facilitate traffic flow in accordance with the planned life (Pradipta,

2021). If during the implementation and use period no damage occurs, it means that road users can use and smooth the road comfortably and safely. So far, there have been many road plans that are not in accordance with the planning so that the road pavement does not last according to the planned life. In order to avoid this, it is necessary to design the right type of pavement planning for the Teuku Umar Road - Rejawali Road (Sampang) Preservation project. So, an analysis is needed to determine the right type of pavement for the Teuku Umar Road - Rejawali Road Preservation project. Based on this background, this study aims to analyze the calculation of planning thickness of rigid pavement construction with a plan age of 20 years and flexible pavement construction using the Road Pavement Design Manual No. 02/M/BM/2017 method for both methods (Abizar & Widodo, 2021).

2. RESEARCH METHODS

The object of this research is to determine the technical calculation, cost and time of Rigid Pavement and Flexible Pavement (Prasetya & Marleno, 2020). The research location on the Teuku Umar Road - Rajawali Road Preservation project in Sampang Regency, East Java Province is geographically located at the coordinates -7.195082 °S 113.245538 °E. Below is a location map sourced from Google Maps. The instrument in the research is the Standard regulations for the calculation of technical structures on Rigid Pavement and Flexible Pavement with the regulations of the Road Pavement Design Manual No. 02/M/BM/2017 (Supriyatno, 2023).

The data collection procedure carried out in this study is secondary data in the form of LHR (Average Daily Traffic) Data, CBR (California Bearing Ratio) Data. The data analysis that will be carried out is a technical analysis of the comparison of Rigid Pavement and Flexible Pavement in terms of implementation costs by comparing the amount of costs incurred with the economic benefits obtained over the next 20 (forty) years (Muhammad, 2021). The calculation method for rigid pavement planning and flexible pavement uses the Road Pavement Design Manual No. 02/M/BM/2017 (Sidabutar et al., 2021).

3. RESULTS AND DISCUSSION

The planning object in this research is the Preservation of Teuku Umar Road - Rajawali Road. The project planning location is located in the Sampanag Regency area of East Java Province. Sampang City is a city with increasingly rapid economic development. The geographical location is the main access for economic transportation routes from Pamekasan district and Sumenep district to Bangkalan district and Surabaya City which is the economic center in East Java.

With the increase in transportation in Sampang city, it is necessary to plan road improvements to facilitate the movement of traffic flow. Traffic movement is a unique and complex interaction between vehicle drivers, roads and the environment. The relationship between these components has different behavior on each type of road, the type of area that makes traffic flow on certain roads always varies. One of the transportation problems that exist in every urban area is unstable road conditions and traffic congestion that occurs almost every day. Road conditions in urban areas are

prioritized by local governments with sustainable infrastructure development (Prahastyo et al., 2019).

The district road planning project through the Sampang Regency Public Works and Spatial Planning Office with the work package Preservation of Teuku Umar Road - Rajawali Road (KM 0+000 to 1+370) is located in Sampang City Center which is the main access to Trunojoyo Terminal and Dr. Muhammad Zyn Hospital. It is expected to overcome the existing transportation problems in Sampang Regency so that the benefits of the project planning can facilitate the main access to the Trunojoyo Terminal area and RSUD dr. Muhammad Zyn and can improve the economy for the people of Madura Island, especially Sampang City.

3.1. Determination of CBR Value

This research was conducted by calculating the thickness of rigid pavement and flexible pavement along 1.370 km using CBR (California Bearing Ratio) data with CBR Laboratory damping testing method used to determine the value of subgrade strength (Soil Supportability). Based on the CBR data obtained, the results of random soil testing obtained CBR values that represent the calculation of the results of field surveys using the CBR Laboratory damping testing method as follows:

Table 1. Laboratory CBR Damping Value

Laboratory CBR Damping Data			
No.	STA	CBR (%)	
		Before Silencing	After Damping
1.	0+150	11,10%	10,19%
2.	0+325	10,15%	9,16%
3.	0+705	11,37%	10,22%
4.	1+050	11,10%	10,75%
5.	1+300	11,18%	9,43%
Average		10,98%	9,95%

Source: PUPR Office of Sampang Regency, 2022

3.2. Pavement Thickness Calculation

The thickness of the pavement in the construction of a road is a construction where the condition of the subgrade is poor so that it is unable to directly withstand the wheel load caused by the weight of the vehicle above it. Pavement calculations in this study determine the thickness of rigid pavement and flexible pavement.

3.3. Calculation of Rigid Pavement Thickness

Planning Data:

Road Length = 1370 meters
Road Width = 10.00 meters
Road Classification = Collector
Road Type = 2 Lanes 2 Undivided Directions (2/2UD)
Traffic Development (i) = 4.5% (MDP 2017)
Age of Plan (UR) = 20 years (MDP 2017)
Subgrade CBR = 9.95%

Table 2. LHR Data of Teuku Umar - Rajawali Road Section

No.	Vehicle Type	Volume
1.	2 Ton Car (1+1)	2836
2.	Bus 9 Ton	46
3.	Truck 18 Ton	2
4.	Truck 25 Ton	0
LHR Year 2023		**2884**

Source: Transportation Department of Sampang Regency, 2024

Planning materials for concrete pavement with reinforcement (BBDT):

Concrete flexural strength (fs) = 4.1 MPa
Concrete flexural tensile strength (fcf) = K x (fs)0.5
= 0,75 x 4,1 0,5
= 1.52 MPa

Where:
K = Constant 0.70 for unbroken aggregate and 0.75 for broken aggregate

- Spokes (Dowel and Tie Bar) = Yes
- Reinforcing Steel Grade = BJTS 280
= BJTP 280
- Foundation Layer (LMC) = Thin Concrete (Lc)
- Subgrade Improvement = Class A Aggregate Material

3.4. Determining the Rigid Pavement Thickness Arrangement

Calculate the distribution of commercial vehicles from the type and axle load and calculate the occurring Axis Repetition and the Plan Axis Repetition.

Table 3. Calculation of Number of Axes Based on Type and Load

Jenis Kendaraan	Konfigurasi Beban Sumbu				Jumlah Kendaraan (bh)	Jumlah Sumbu per Kendaraan	Jumlah Sumbu (bh)	STRT		STRG		STdRG	
	RD	RB	RGD	RGB				BS (Ton)	JS (Bh)	BS (Ton)	JS (Bh)	BS (Ton)	JS (Bh)
a	b	c	d	e	f	g	h = f x g	i = b	j = f	k = c	l = f	m = c	n = f
Mobil 2 Ton (1+1)	1	1	-	-	2836	-	-	-	-	-	-	-	-
Bus 9 Ton (3+6)	3	6	-	-	46	2	92	3	46	6	46	-	-
Truck 18.2 Ton (6.2+12)	6,2	12	-	-	2	2	4	6,2	2	12	2	-	-
Truck 25 Ton (6.2+18.8)	6,2	-	-	18,8	0	2	0	6,2	0	-	-	18,8	0
Truck 42 Ton (7.6+11.8+22.6)	7,6	11,8	-	22,6	0	3	0	7,6	0	11,8	0	22,6	0
							96		48		48		0

Source: Researcher Calculation Results, 2024

Description:
RD = Front Wheel
RB = Rear Wheel
RGD = Front Double Wheel
RGB = Rear Wheel Drive
BS = Axis Load
JS = Number of Axes
STRT = Single Axis Single Wheel
STRG = Dual Wheel Single Axis
STdRG = Dual Wheel Tandem Axis

Number of Commercial Vehicle Axes (JSKN) over a 20-year life:

$$R = \frac{(1+0{,}01 \text{ x } i)^{UR}}{0{,}01 \text{ x } i} - 1$$
$$= \frac{(1+0{,}01 \text{ x } 4{,}5\%)^{20}}{0{,}01 \text{ x } 4{,}5\%} - 1$$
$$= 20{,}09$$

JSKN = 365 x JSKNH x R
= 365 x 96 x 20,09
= 703.804,03

R = Trafic Growth Factor

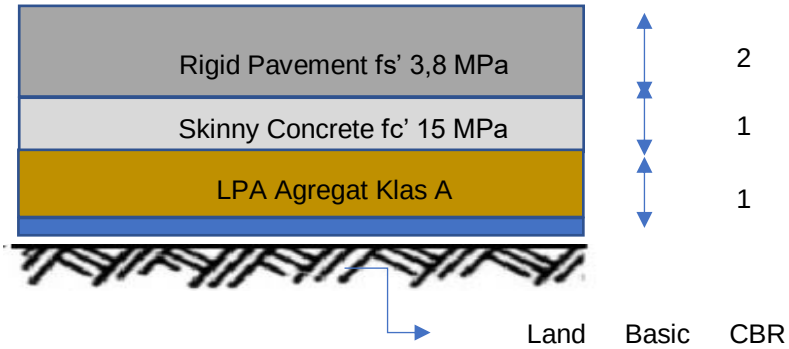
JSKN Ren = C x JSKN
= 0,50 x 703.804,03
= 351.902,01 < 43.000.000

Where:
C = Vehicle Distribution Coefficient For Plan Road Width
10.00 meters < Lp < 8.25 □ With Number of Lanes 2, 2 Directions
C value = 0.50

Table 4. Planning Catalog

Description	Road Criteria		
	Local Road	**Collector Road**	**Special Road** [3)]
1. LHR_N	< 50	50 – 500	≥ 500
2. Load MST [1)]	Max. 5 Ton	Max. 8 Ton	Max. 12 Ton
3. Thickness of Concrete	150 mm	200 mm	230 mm
4. Minimum bending strength, *Sc*	3,5 (MPa)	3,8 (MPa)	4,1 (MPa)
5. Thickness of skinny concrete [2)]	50 mm	100 mm	100 mm
6. Bottom Layer Thickness — CBR subgrade, 4% ≤ CBR < 6%	250 mm	250 mm	250 mm
6. Bottom Layer Thickness — CBR subgrade, CBR ≥ 6%	150 mm	150 mm	150 mm

Source: SNI 8457:2017



Source: Researcher Calculation, 2024

Figure 1: Rigid Pavement Design

3.5. Design Dimensions of Dowel and Tie bars

a. Dowel Dimensions

This connection must be provided with 45 cm long plain spokes, the distance between the spokes 30 cm, straight and free from sharp protrusions that will affect free movement when the concrete slab shrinks. Half the length of the plain spokes must be painted or coated with an anti-rust material to ensure that there is no bond with the concrete.

Table 5. Planning Catalog

Description		Road Criteria		
		Local Road	Collector Road	Special Road [3)]
Transverse Connection Distance (m)		4,0	4,0	4,0
Tie bars	Min. steel grade (MPa)	BjTS 280	BjTS 280	BjTS 280
	Diameter, ø (mm)	13	16	16
	Length, L (mm)	600	700	700
	Spacing, S (mm)	750	750	750
Dowel	Min. steel grade (MPa)	Without Spokes	BjTP 280	BjTP 280
	Diameter, ø (mm)		25	28
	Length, L (mm)		450	450
	Spacing, S (mm)		300	300

Source: SNI 8457:2017

b. Tie bars dimensions

For tie bars using screw iron with a diameter of Ø 16 mm, the quality of BjTS steel is 280 MPa, with the length of the tie bars being 700 mm and the pair distance being 750 mm. The length of the tie bar can be calculated using the formula:

$$I = (38{,}3 \times \Phi) + 75$$
$$= (38{,}3 \times 16) + 75 = 687{,}8 \text{ mm} = 700 \text{ mm}$$

3.6. Calculation of Flexible Pavement Thickness

Planning Data:

Road Status = County Road
Road Type = 2/2 UD
Road Classification = Collector Road
Traffic Growth = 3.5%
Plan Age = 20 Years
Road Body Width = 10.00 meters

Characteristic CBR analysis using the standard normal distribution method with the formula as folows:

Table 6. Adjustment Factor of Subgrade Modulus to Seasonal Conditions

Season	Minimum adjustment factor of CBR value
Rainy Season and Saturated Soil	0,90
Transition Period	0,80
Dry Season	0,70

Source: Pavement Design Manual, 2017

Design CBR value = (test result CBR) x adjustment factor
Characteristic CBR = Average CBR - f x Standard Deviation
Value of f = 1.282 For Collector and Arterial Roads
CBR value Adjustment Factor = 0.90 (Rainy season)

Table 7. Characteristic CBR values

Point	CBR (%)	CBR Adjustment (%)	Average CBR (%)	Standard Deviation	Value of f	Characteristic CBR (%)
1.	10,19	9,17				
2.	9,16	8,24				
3.	10,22	9,20	8,96	0,519	1,282	8,29
4.	10,75	9,68				
5.	9,43	8,49				

Source: Researcher Processed Data, 2024

3.7. Traffic Analysis

Table 8. Traffic Growth Rate Factor (i) (%)

	Java	Sumatra	Kalimantan	Indonesia 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

Source: Pavement Design Manual, 2017

I = 3.5% (Rural Collector)
DD = 0.5 (Direction distribution factor for 2-way roads)
DL = 50% (Lane distribution factor for the number of lanes in each direction)
R(2024-2044) = 28.28 (Traffic growth multiplier factor cumulative traffic growth in 2024-2044)

ESA 4 and ESA 5 Traffic Analysis
ESA = (∑LHR x VDF) x 365 x DD x DL x R

Table 9. Cumulative Axis Load

Vehicle Type	LHR	LHR 2044	VDF 4	VDF 5	ESA 4	ESA 5
	2024	(20 Year)	Factual	Factual	Yr. '23-'43	Yr. '23-'43
Light Vehicle Type 1,2,3,4	2985	5940	-	-	-	-
Type 5A	-	-	0,30	0,20	-	-
Type 5B	-	-	1,20	1,30	-	-
Type 6A	-	-	0,50	0,40	-	-
Type 6B	-	-	2,00	2,70	-	-
Type 7A	-	-	15,70	31,30	-	-
Type 7B	-	-	17,60	28,90	-	-
Type 7C	-	-	21,00	37,10	-	-
	Number of Esa				-	

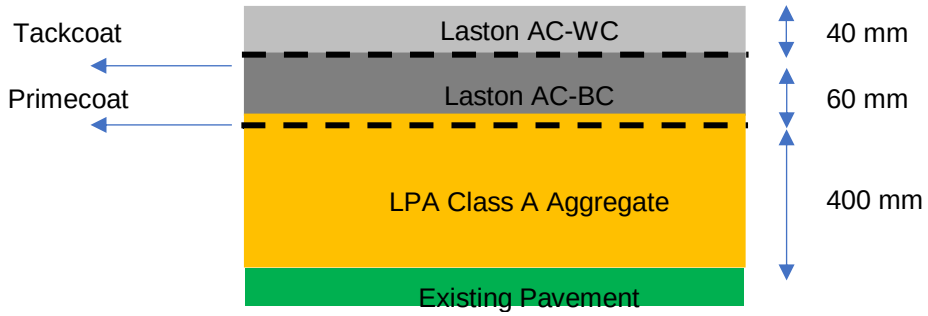
Source: Researcher Processed Data, 2024

3.8. Pavement Layer Design

Table 10. Design Chart of Flexural Pavement - Asphalt with Graded Foundation Layer

	Pavement Structure							
	FFF1	FFF2	FFF3	FFF4	FFF5	FFF6	FFF7	FFF8
Solution chosen				See Notes 2				
Cumulative 20-year axle load on plan lanes (10^ESA5)	< 2	≥2-7	>7-10	>10-20	>20-30	>30-50	>50-100	>100-200
Pavement 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 Kelas A	400	300	300	300	300	300	300	300
Note	1		2	3				

Source: Pavement Design Manual, 2017



Source: Researcher's calculation, 2024

Figure 2. Flexural Pavement Design

4. CONCLUSION

Based on the results of the research analysis that has been carried out on the Teuku Umar Road Preservation project - Rajawali Road, Sampang Regency, by analyzing the thickness of the pavement with the Road Pavement Design Manual Method No. 02 / M / BM / 2017. The results of the technical calculation analysis on the thickness of Rigid Pavement, among others:

Thick concrete fs' 3.8 MPa = 200 mm
Thin concrete fc' 15 MPa = 100 mm
Class A aggregate LPA = 150 mm

While the results of the analysis of technical calculations on the thickness of Flexible Pavement, among others:

AC-WC Laston Thickness = 40 mm
AC-BC Laston Thickness = 60 mm
Class A Aggregate LPA = 400 mm

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