Analysis of Flexible Pavement on the Wassu-Oma Road Section, Haruku Island District, Central Maluku Regency

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Abstract- **Road Wassu-Oma is one of the roads in Haruku Island District, Central Maluku Regency. One of the important infrastructure access is road transportation. The road section on Haruku Island with inadequate road conditions is the Wassu-Oma road section. The road connects Wassu and Oma with a road length of 5.425 km, starting from STA 0+00 – STA 0+5425 and a road body width of 6.5 m. The status of the road is still a dirt road, with the condition of the road affecting the travel time of road users. Therefore, the Wassu-Oma Road section, Haruku Island Sub-District, Central Maluku Regency, will be upgraded *from* the status of a red dirt road to *Asphal t Concrete Wearing Course* (AC-WC) pavement with a flexible pavement type . This study aims to determine the thickness of the flexible pavement on the Wassu-Oma road section, Haruku Island sub-district, Central Maluku Regency using the 2017 Pavement Design Manual Method. Based on the analysis results obtained from flexible pavement analysis and the Budget Plan for the Wassu-Oma road section, Pulau Haruku District, Central Maluku Regency STA 0+000 – STA 5+425, the CESA5 (Cumulative Equivalent Single Axle) value for each commercial vehicle for 20 years from 2023 – 2043 is obtained, namely the value of traffic on the planned lane of 24,111.90 or 0.02 Million ESA5, the thickness of the surface layer AC-WC is 40 mm, AC-BC layer thickness is 60 mm, and class A foundation layer thickness *is* 400 mm.**

Keywords: **Dirt Road , Thickness of Flexible Pavement, MDP 2017**

I . INTRODUCTION

Flexible pavement is a type of pavement that uses asphalt as a binder [4] . Flexible pavement construction consists of layers placed on compacted subgrade. These layers function to receive traffic loads and pass them on to the layers below them. Flexible pavement construction consists of types of pavement construction based on the binding material which can be differentiated into surface course , base *course* , *sub base course* , *subgrade* [4].

The Wassu-Oma road section is inadequate and is still in the condition of a red dirt road (macadam), so access to the road can only be passed by pedestrians while land vehicles cannot access it. In order to improve the economy [3] , [5] of Wassu and Oma countries, it is necessary to have road infrastructure and facilities that must be permanent. If the road condition is still a red dirt road (macadam), it will take travel time, so it is necessary to increase the road section. The existing condition of this road section is 5.425 km long , from STA 0+00 to STA 5+425 and the width of the road body is 6.5 m.

Based on the description above, the Wassu-Oma Road section will be upgraded to *Asphalt Concrete Wearing Course (AC-WC) pavement with a flexible pavement* type. In this pavement thickness analysis, the 2017 Pavement Design Manual method MDP will be used.

II . METHODS

Research sites

This research was conducted on the Wassu-Oma road section, Haruku Island District, Central Maluku Regency, 5.425 km long , from STA 0+000 – STA 5+425.

LHR Survey Locations

The location of the LHR survey was carried out on the Waerian-Kailolo road section, Haruku Island District, Central Maluku Regency which was marked with survey point A (TS 1 to TS 2) and survey point B (TS 2 to TS 1) with a survey point distance of 500 m.

Research locations and survey locations can be seen in Figure 1 below:

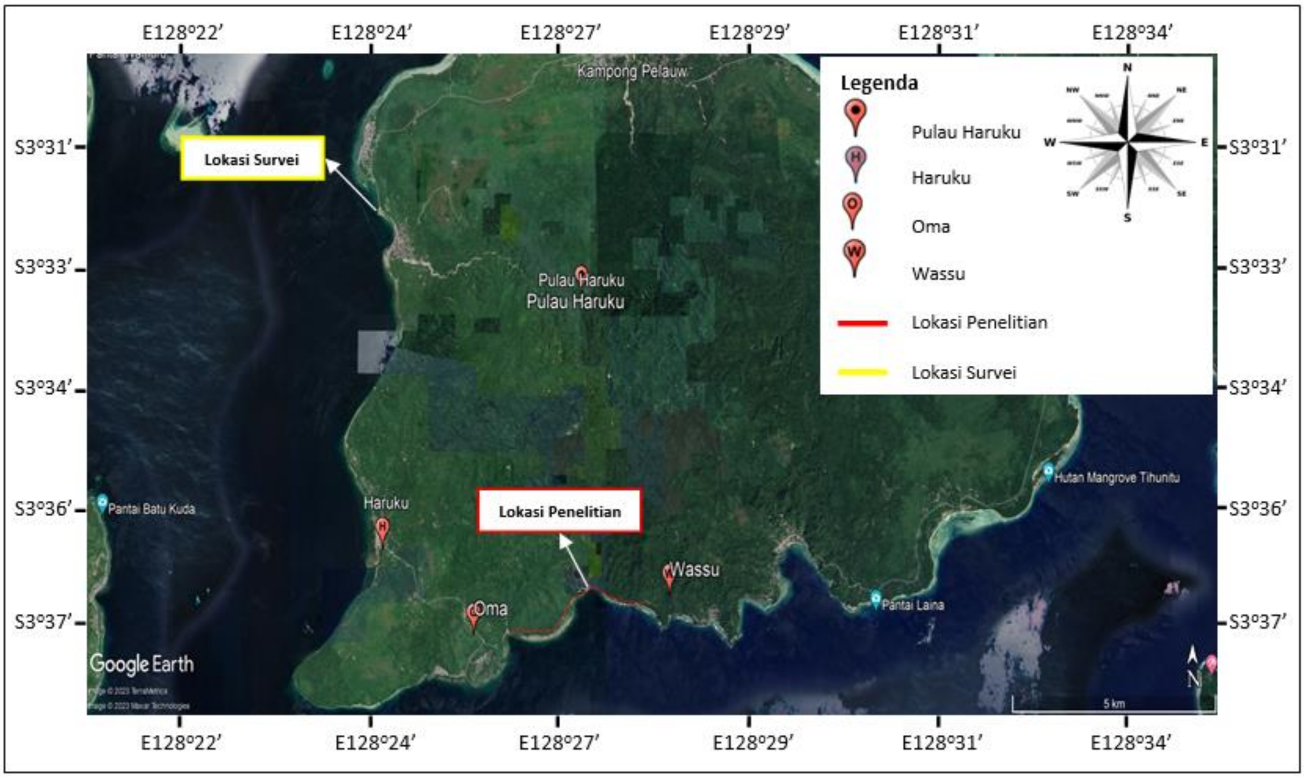

Figure 1 LHR research locations and survey locations.
https://maps.app.goo.gl/ SiH3xdvfgEh59CBA8

Data Type

a. Qualitative Data

Qualitative data is data that is descriptive in nature, cannot be measured by numbers and is usually in the form of words. this data in the form of data obtained directly from survey results in the field , namely Average Daily Traffic Data (LHR) .

b. Quantitative Data

Quantitative data is information that can be measured, calculated and compared on a numerical scale.

Data collection technique

Data collection techniques used in this research are the following methods:

a. Observation Method

That is the method by conducting a direct survey to the research location assisted by several surveyors on the Waerian-Kailolo road section, Haruku Island District, Central Maluku Regency for types of light vehicles, heavy vehicles and motorcycles. The survey was conducted for 3 days with the following description:

1. Monday 06.00 – 18.00 WIT
2 . Wednesday 06.00 – 18.00 WIT
3 . Saturday 06.00 – 18.00 WIT

b. Library Method

Namely collecting scientific works in the form of books, journals, theses, theses and regulations related to planning.

Data source

a. Primary data

Primary data is data obtained directly from survey results in the field. The primary data obtained is Average Daily Traffic Data (LHR) .

b. Secondary data

Secondary data is data obtained from literature study and data obtained from the Implementing Contractor of PT. Adhy Daya Evaniatama, namely plan drawing data, excavation and embankment volume data, from the Planning Consultant CV. Griya Persada with the data obtained, namely the subgrade CBR, and from the BMKG Amahai meterological station, the data obtained were rainfall data.

Research variable

In this study, two variables were used, namely the independent variable and the dependent variable.

a. *dependent* variable is the variable (effect) that is presumed, generally a condition to be disclosed, namely the thickness of the Road Pavement.

b. The independent variable *is* the variable that is seen as the cause of the emergence of the dependent variable which is suspected as a result, namely Plan Age, Traffic growth, vehicle volume.

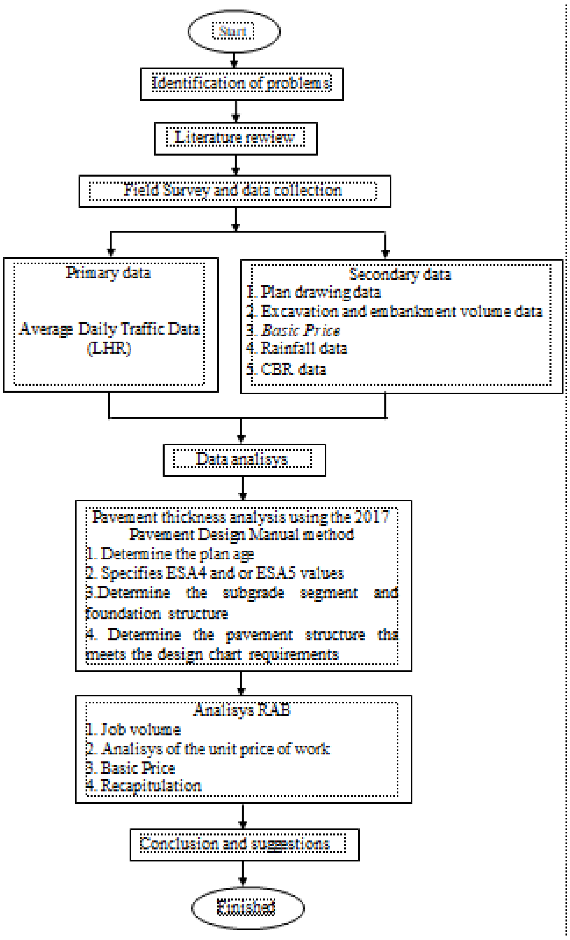

Figure 2 Research flowchart

Analysis Method

The analytical method used to determine the thickness of the flexible pavement is as follows:
Determine the thickness of flexible pavement using the 2017 Pavement Design Manual (MDP) . [2] .

a. Determine the plan age
b. Determine the values of ESA4 and or ESA5 according to the selected plan age
c. Determine the type of pavement based on the pavement type selection table or cost considerations (*discounted life-cycle* cost analysis)
d. Determine subgrade segments with uniform carrying capacity
e. Determine the pavement foundation structure
f. Determine the required pavement structure from design chart 3 or other appropriate design charts .

Figure 3 Condition of the Wassu-Oma road at STA 3+325 – 3+350

Flexible pavement is a type of pavement that uses asphalt as a binder. Flexible pavement construction consists of layers placed on compacted subgrade. These layers function to receive traffic loads and pass them on to the layers below them. Flexible pavement construction consists of types of pavement construction based on the binding material which can be differentiated l surface *course* , l base *course* , l sub *base* course , l sub *grade* [4] . in order to obtain results that are in accordance with the expected quality, knowledge about the nature, procurement and management of road pavement constituent material is very necessary[6].

Flexible Pavement Planning Procedure

The procedure for planning flexible pavements to achieve technically optimal and economically optimal results is as follows [2] :

a. Determine the plan age .

The planned age of road pavement is a measure of the amount calculated in years starting from the time the road is opened for vehicle traffic until a structural road repair is required (Pavement overlay is required). During the life og the plan, road pavement maintenance is still necessary and must continue to be carried out, such as non-structural coatings that function as wear layers. The design life for flexible pavement planning for new roads is generally set at 20 years or maybe only 10 years is sufficient, while for road improvements the design age is 10 years. Based on the table of the new road pavement (UR) design life, flexible pavement types have a design life of 20 years.

b. Determine the values of ESA4 and or ESA5 according to the selected plan age .

The design thickness of the pavement is based on ESA values of the 4th and 5th power depending on the deteriotion model *and* the design approach used. Use the appropriate ESA value as input in the planning process [2] .

Traffic volume analysis

Traffic volume is defined as the number of vehicles that pass one observation point for one time unit (day, hour or minute). Average daily traffic is the average traffic volume in one day. From the length of observation time to get the average daily traffic value, There are two types of traffic known average daily namely [4] :

1) Annual Average Daily Traffic (LHRT), namely the daily traffic volume obtained from the average value of the number of vehicles for a full year.

$$LHRT = \frac{Jumlah\ kendaraan\ dalam\ 1\ tahun}{365} \quad (1)$$

LHRT is stated in vehicles/day/2-way for 2-lane roads without a median or vehicles/day/way for 2-lane roads with a median.

2) Average Daily Traffic (LHR), namely the daily traffic volume obtained from the average value of the number of vehicles for several days of observation.

$$LHR = \frac{Jumlah\ kendaraan\ selama\ pengamatan}{Jumlah\ hari\ pengamatan} \quad (2)$$

LHR data is quite accurate if observations are made at time intervals that can describe fluctuations in traffic flow for 1 year and the LHR results used in planning are the average price of several observations or have gone through traffic studies.

Traffic data

The accuracy of traffic data is important to produce a pavement design that can work well over the life of the plan. Therefore the calculation of traffic data must include all types of traffic vehicles. The classification of traffic vehicles based on their types is described in Table 1 below.

Table 1 Classification of vehicles by type [2]

class	Transportation type
1	Motorcycle
2,3,4	Private car / Angkot / Pickup / Station Wagon
5A	Little Bus
5B	Big Bus
6A	2 axle truck – light cargo
6B	2 axle truck – heavy cargo
7A	3 axle truck
7B	2 axle truck & 2 axle towing trailer (Article Truck)
7C	4 Axle Truck – Trailer

traffic flow

Department of Public Works Indonesia Road Capacity Manual (1997) states that if the traffic flow is converted from vehicles per hour to units of passenger cars (SMP) using passenger vehicle equivalents (EMP) [7] .

Table 2 Passenger Car Equivalent

Transportation type	EMP
Motorcycle (MC)	0.5
Light vehicles (LV)	1.0
Heavy vehicles (HV)	1,3

Traffic growth factor

The traffic growth factor is based on serial growth data (*historical growth* data) or a correlation formulation with other applicable growth factors. If data is not available, then the traffic growth rate factor table can be used. The traffic growth factor used in calculating the thickness of the flexible pavement for Jalan Wassu-Oma is the status of village roads in the average area of Indonesia with a traffic growth factor (i) of 1.00% [*2*] .

Traffic growth over the life of the plan is calculated by the cumulative growth factor *(Cumulative Growth Factor*):

$$R = \frac{(1+0{,}01\,i)^{UR}-1}{0{,}01\,i} \quad (3)$$

With:

R = cumulative traffic growth multiplier factor
i = annual traffic growth rate (%)
UR = design age (years)

If it is estimated that there will be a difference in the annual growth rate over the total design life (UR) with i_1 % during the initial period (UR1 year) and i_2 % during the remainder of the following period (UR – UR1), the cumulative traffic growth multiplier factor can be calculated from the following formula [2] :

$$R = \frac{(1+0{,}01\,i)^{UR}-1}{0{,}01\,i} + (1+0{,}01\,i_1)^{(UR1-1)}(1+0{,}01\,i_2)\left\{\frac{(1+0{,}01 i_2)^{(UR-UR1)}-1}{0{,}01 i_2}\right\} \quad (4)$$

With:

R = cumulative traffic growth multiplier factor
i_1 = annual growth rate of traffic period 1 (%)
i_2 = annual growth rate of traffic period 2 (%)
UR = total design life (years)
UR1 = design life period 1 (year)

If the traffic capacity is estimated to be reached in year (Q) of the design life (UR), the cumulative traffic growth multiplier factor is calculated as follows:

$$R = \frac{(1+0{,}01\,i)^{Q}-1}{0{,}01\,i} + (UR-Q)\,(1+0{,}01\,i)^{(Q-1)} \quad (5)$$

Traffic on the planned lane

The design lane is one of the traffic lanes of a road section that accommodates the most commercial vehicle traffic (trucks and buses). The traffic load on the planned lane is expressed in cumulative standard axle load (ESA) taking into account the direction distribution factor (DD) and commercial vehicle lane distribution factor (DL) which can be seen in the following table.

Table 3 Lane distribution factor (DL) [2]

Number of Lanes every direction	Commercial vehicle on design lane (% of commercial vehicle population)
1	100
2	80
3	60
4	50

VDF value of each type of commercial vehicle

Table 4 VDF of each commercial vehicle [2]

No.	Transportation type	Maluku
		Normal
		VDF 5
1.	Motorcycle	-
2.	Private vehicle	-
3.	Public transport	-
4.	Mini buses	-
5.	Pick Up/Box	-
6.	Big buses	1.00
7.	2 axle truck	0.50
8.	3 axle truck	3.00
9.	Trailer truck	-
10.	Tronton truck	0.80

Traffic forecast for low traffic roads

Table 5 Traffic estimates for low traffic roads

Deskripsi Jalan	LHR dua arah (kend/hari)	Kendaraan berat (% dari lalu lintas)	Umur Rencana (th)	Pertumbuhan Lalu Lintas (%)	Faktor Pengali Pertumbuhan kumulatif lalu lintas	Kolompok Sumbu/Kendaraan Berat	Kumulatif HVAG (kelompok sumbu)	Faktor ESA/HVAG	Beban Lalu lintas desain (aktual) (ESA4)
Jalan desa minor dengan akses kendaraan berat terbatas	30	3	20	1	22	2	14.454*	3,16	$4{,}5 \times 10^4$
Jalan kecil dua arah	90	3	20	1	22	2	21.681	3,16	7×10^4
Jalan lokal	500	6	20	1	22	2.1	252.945	3,16	8×10^5
Akses lokal daerah industri atau *quarry*	500	8	20	3.5	28.2	2.3	473.478	3,16	$1{,}5 \times 10^6$
Jalan kolektor	2000	7	20	3.5	28.2	2.2	1.585.122	3,16	5×10^6

Determine the type of pavement based on the pavement type selection table or cost considerations.

The choice of pavement type will vary based on traffic volume, design age, and road foundation conditions. Selection of design alternatives based on this manual must be based on the lowest *discounted lifecycle cost* [2].

Table 6 Selection of pavement types

Struktur Perkerasan	Bagan Desain	ESA (juta) dalam 20 tahun (pangkat 4 kecuali ditentukan lain)				
		0 – 0,5	0,1 - 4	>4 - 10	>10 – 30	>30 - 200
Perkerasan kaku dengan lalu lintas berat (di atas tanah dengan CBR ≥ 2,5%)	4	-	-	2	2	2
Perkerasan kaku dengan lalu lintas rendah (daerah pedesaan dan perkotaan)	4A	-	1,2	-	-	-
AC WC modifikasi atau SMA modifikasi dengan CTB (ESA pangkat 5)	3	-	-	-	2	2
AC dengan CTB (ESA pangkat 5)	3	-	-	-	2	2
AC tebal ≥ 100 mm dengan lapis fondasi berbutir (ESA pankat 5)	3B	-	-	1,2	2	2
AC atau HRS tipis diatas lapis fondasi berbutir	3A	-	1,2	-	-	-
Burda atau Burtu dengan LPA kelas A atau batuan asli	5	3	3	-	-	-
Lapis Fondasi Soil Cement	6	1	1	-	-	-
Perkerasan tanpa penutup (Japat, jalan kerikil)	7	1	1	-	-	-

Determine subgrade segments with uniform carrying capacity

Roads in the longitudinal direction can travers different types of soil and diferrent terrain conditions. The quality of the carryng capacity of the subgrade can vary from bad to good or vice versa. Thus it is not economical if the road pavement layer thickneess planning ia based on the worst value and also does not meet the requirements if it is only based on the largest value. Therefore the subgrade modulus value obtained from the DCP must be adjusted to seasonal conditions. Minimum adjustment factor . The Wassu-Oma road is classified as a wet season condition and the soil is saturated with a minimum adjustment factor for the CBR value based on the DCP test, which is 0.90. [1]

Design CBR value = (CBR DCP test results) x adjustment factor [2]

Table 7 Determination of the minimum road foundation design [2]

<table>
<tr><th rowspan="4">CBR Tanah dasar (%)</th><th rowspan="4">Kelas kekuatan Tanah Dasar</th><th rowspan="4">Uraian Struktur Fondasi</th><th colspan="3">Perkerasan Lentur</th><th>Perkerasan Kaku</th></tr>
<tr><th colspan="3">Beban lau lintas pada lajur rencana dengan umur rencana 40 tahun (juta ESA5)</th><th rowspan="3">Stabilisasi Semen (6)</th></tr>
<tr><th>< 2</th><th>2 - 4</th><th>> 4</th></tr>
<tr><th colspan="3">Tebal minimum perbaikan tanah dasar</th></tr>
<tr><td>≥ 6</td><td>SG6</td><td rowspan="6">Perbaikan tanah dasar dapat berupa stabilassi semen atau material timbunan pilihan (sesuai persyaratan Spesifikasi Umum, Devisi 3 – Pekerjaan Tanah) (pemadatan lapisan ≤ 200 mm tebal gembur)</td><td colspan="3">Tidak diperlukan perbaikan</td><td rowspan="5">300</td></tr>
<tr><td>5</td><td>SG5</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>4</td><td>SG4</td><td>100</td><td>150</td><td>200</td></tr>
<tr><td>3</td><td>SG3</td><td>150</td><td>200</td><td>300</td></tr>
<tr><td>2,5</td><td>SG2.5</td><td>175</td><td>250</td><td>350</td></tr>
<tr><td colspan="2">Tanah ekspansif (potensi pemuaian > 5%)</td><td>400</td><td>500</td><td>600</td><td rowspan="4">Berlaku ketentuan yang sama dengan fondasi jalan perkerasan lentur</td></tr>
<tr><td rowspan="2">Perkerasan di atas tanah lunak(2)</td><td rowspan="2">SG1 (3)</td><td>Lapis penopang(4)(5)</td><td>1000</td><td>1100</td><td>1200</td></tr>
<tr><td>-atau- lapis penopang dan geogrid (4) (5)</td><td>650</td><td>750</td><td>850</td></tr>
<tr><td colspan="2">Tanah gambut dengan HRS atau DBST untuk perkerasan untuk jalan raya minor (nilai minimum – ketentuan lain berlaku)</td><td>Lapis penopang berbutir(4) (5)</td><td>1000</td><td>1250</td><td>1500</td></tr>
</table>

Table 8 Determination of the 3B design chart [2]

	STRUKTUR PERKERASAN								
	FFF1	FFF2	FFF3	FFF4	FFF5	FFF6	FFF7	FFF8	FFF9
	Solusi yang dipilih				Lihat catatan 2				
Komulatif beban sumbu 20 tahun pada lajur rencana (10^6 ESA5)	< 2	≥ 2 - 4	> 4 - 7	> 7 - 10	> 10 - 20	> 20 - 30	> 30 - 50	> 50 - 100	> 100 - 200
KETEBALAN LAPIS PERKERASAN (mm)									
AC WC	40	40	40	40	40	40	40	40	40
AC BC	60	60	60	60	60	60	60	60	60
AC Base	0	70	80	105	145	160	180	210	245
LPA Kelas A	400	300	300	300	300	300	300	300	300
Catatan	1		2		3				

III . DATA AND ANALYSIS

Pavement thickness analysis data

a. Type of planned road = Class III C village road (Collector) [4]
b. Pavement thickness = 2 lanes 2 directions
c. Pavement type = flexible pavement
d. Soil CBR value = 10.27 % (CV.Griya Persada).
e. Average Daily Traffic Data (LHR) = LHR data is carried out by direct surveys in the field

Pavement thickness analysis

The analysis of the pavement layer in this study connects the Wassu-Oma road section which refers to the 2017 Road Pavement Design Manual published by the Directorate General of Highways.

a. Determine the plan age

Determination of the planned age is adjusted to the type of pavement and pavement elements to be planned. The design life used based on provisions on new flexible pavement is 20 years [2].

b. Calculates the ESA5 value

1. Average daily traffic

The average daily traffic data used is the Waerian - Kailolo road data. Based on the results of a traffic survey conducted for 3 days at two observation posts TS 1 and TS 2.

Figure 4 LHR Survey at the TS-1 and TS-2 Observation Posts on the first day

Figure 5 LHR S urvey at the TS-1 and TS-2 Observation Posts on the second day

Figure 6 LHR S urvey at the TS-1 and TS-2 Observation Posts on the third day

Traffic growth factor

The planning of the road connecting Wassu-Oma is a village road based on the traffic growth rate factor table, the status of the road is classified as a village road with a traffic growth factor value of 1.0%.

Traffic growth during the design life is calculated by the cumulative growth factor *which* can be seen in the formula equation as follows [2] :

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

$$R = \frac{(1 + 0{,}01\ i)^{UR}-1}{0.01\ i} = \frac{(1 + 0{,}01\ x\ 1{,}00)^{20}-1}{0.01\ x\ 1{,}00} = 22.02$$

So the value of the cumulative traffic growth multiplier factor (R) is 22.02 .

2. Direction distribution factor and lane distribution

The planned number of lanes and lanes is 2 lanes 2 directions. So based on the 2017 Pavement Design Manual for 2-way roads, the value of the directional distribution factor (DD) taken 50%. And based on the lane distribution table, the lane distribution factor (DL) value used is 100% for one lane in each direction [2] .

3. ESA5 Value Calculation

The ESA5 value with the VDF value of each commercial vehicle can be calculated using the following formula [2] :

$$ESA5 = LHR\ x\ VDF\ x\ 365\ x\ DD\ x\ DL\ x\ R \quad (6)$$

The results of calculating the ESA5 value for each commercial vehicle and the total ESA5 or also called CESA5 for 20 years from 2023 – 2043 can be seen in table 8 below.

Table 9 Calculation of ESA5 values

NO.	Transportation type	EMP		LHR 20 22		LHR 202 3		VDF5 Normal	ESA5 (2043)
				Vehicle	JUNIOR HIGH SCHOOL	Vehicle	JUNIOR HIGH SCHOOL		
1 .	Motorcycle	MC	0.5	3,898	1949	3,976	1988,17	-	-
2 .	Private vehicle	LV	1.0	53	53	54	54.07	-	-
3 .	Public transport	LV	1.0	78	78	80	79.57	-	-
4 .	Minibuses	LV	1.0	0	0	0		-	-
5 .	Pick Up/Box	LV	1.0	65	65	66	66	-	-
6 .	Big Bus	HV	1,3	0	0	0	0	1.00	-
7.	2 Axis Truck	HV	1,3	12	15,6	12	15,6	0.50	24,111.90
8.	3 Axis Truck	HV	1,3	0	0	0	0	3.00	0
9.	Trailer Truck	HV	1,3	0	0	0	0	-	-
10.	Troton truck	HV	1,3	0	0	0	0	8.80	-
CESA5 202 3 -204 3									**24,111.90**

Source :

a. Determine the pavement type

The choice of pavement type is influenced by traffic volume, design age, and road foundation conditions [2] . So with a design life of 20 years and a traffic value on the design lane of 24,111.90 or 0.02 Million ESA5. Then based on the pavement type selection table, the pavement structure for AC roads is ≥ 100 mm thick with a granular layer based on the 3B design chart.

b. Determine the pavement foundation design

California Bearing Ratio (CBR) value of the subgrade used is data on the Wassu-Oma road . Based on data from the Department of Public Works for Highways in Central Maluku Regency, a characteristic CBR value of 10.27% was obtained. So that with a subgrade CBR value of 10.27% entered in the row in the table with a subgrade CBR value ≥ 6 and a traffic value on the planned route of 0.04 Million ESA5, then based on the minimum road foundation design table, the subgrade strength class is SG6 and no subgrade improvement is needed for flexible pavement.

c. Determine the pavement structure that meets the requirements

From the results of ESA5 24,111.90 or 0.02 million and a design life of 20 years, it can be seen in the Table of Determination of design chart – 3B of flexible pavement – bitumen with a grain foundation layer.

From the pavement structure table FFF1 with a cumulative 20-year axle load on the design lane (10^6 ESA5) < 2 million, the thickness of the pavement layer and the cross-section of the road to be used in the planning of the Wassu-Oma road section can be obtained, which can be seen in Figures 7 and 8 below:

AC-WC = 40mm
AC-BC = 60mm
AC-Base = 0 mm
L P A Class A = 4 00 mm

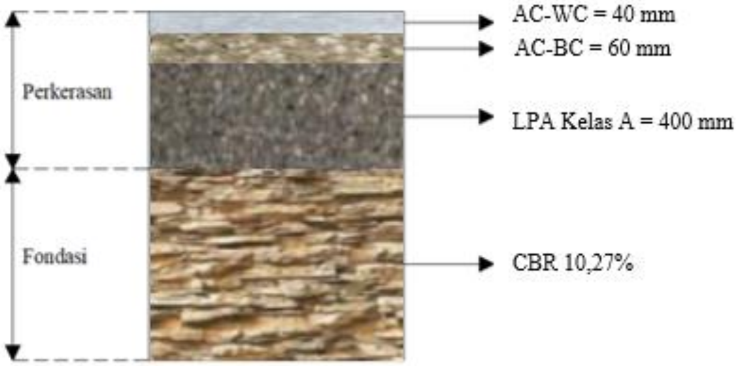

Figure 7 Design sketch of the Wassu-Oma road pavement structure based on the 2017 MDP

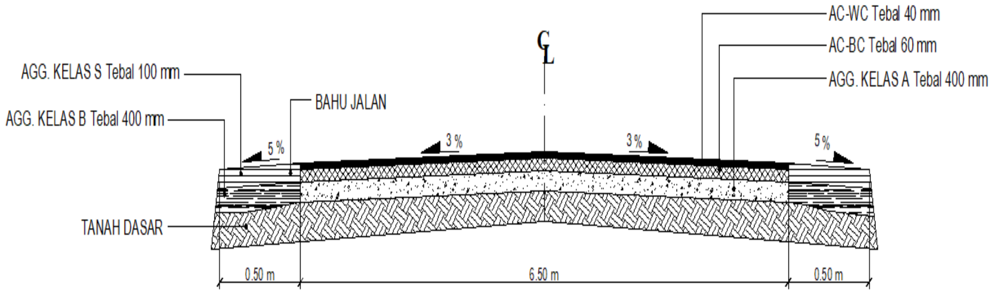

Figure 8 Cross section of the Wassu-Oma road section based on the 2017 MDP

IV. CONCLUSION

Based on the results of the analysis and discussion, the writer draws a conclusion From analysis of flexible pavement sections of Wassu - Oma Road , Haruku Island District (STA 0+000 – STA 5 +425) using the 2017 Pavement Design Manual (MDP 2017) method, namely :

a. ESA5 value for each commercial vehicle and total ESA5 or also called CESA5 for 20 years from 2023 – 2043 traffic on the planned lane is 24,111.90 or 0.02 Million ESA5.

b. The cumulative axle load of 20 years on the design lane (10^6 ESA5) < 2 million, so the thickness of the pavement layer and the cross section of the road to be used in the planning of the Wassu-Oma road section is obtained is thick surface coat AC-WC is 40 mm thick layer AC-BC as big as 60 mm, and the thickness of the class A foundation layer is 400 mm.

V. ACKNOWLEDGMENTS

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