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Analysis of Damage to Banggoi-Bula Road Section Eastern Seram District

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ABSTRACT

Conditions on the Banggoi-Bula Road, Eastern Seram Regency. Suffering from sinking damage, longitudinal cracks and crocodile skin. And the road was widened from the direction of the village of Jakarta Baru to the city of Bula, because the contour of the road was very extreme. The aim of this research is to analyze the type and level of damage, plan the culverts at STA 44+645, 45+400, 45+350 and determine the thickness of the pavement layer on the Banggoi-Bula Road section. The research can determine the type of damage on the Banggoi – Bula STA 43+350 and STA 25+213-25+800 roads loaded using the PCI method, determine the thickness of flexible pavement on the Banggoi-Bula Road section using the 2017 Pavement Design Manual method, and determine planning culverts on the Banggoi-Bula Road. After observing the condition of the road pavement surface that occurred on the Banggoi-Bula Road section, the types of damage were subsidence, longitudinal cracks and crocodile skin cracks. on the Jakarta Baru-Bula Road section starting from STA 43+350, 25+213-25+800 after averaging segment 1 at 20% Very bad level of damage (very bad), segment 2 PCI value at 53% Moderate level of damage (fair), and the PCI segment 3 value is 47%. The level of damage is moderate (fair), so the level of damage is bad so that appropriate handling is based on the 2017 Bina Marga method, which is included in the regular maintenance program. From the research results, the dimensions of the culvert channels at STA 44+645, 45+400, and 45+350 were found to be 1.5 m/sec, with a discharge of 4.0187. and from the results of the flexible pavement research analysis, the traffic value on the planned lane is 769,688.64 or 0.76 million ESA5, the thickness of the AC-WC surface layer is 40 mm, the thickness of the AC-BC layer is 60 mm and the thickness of the class A foundation layer is 400 mm.

1. INTRODUCTION

The Banggoi-Bula Road section is a provincial road in the Eastern Seram Regency with a length of 47,927 km consisting of the Banggoi-Jakarta Baru and Jakata Baru-Bula roads. The Banggoi-Jakarta Baru STA 45 + 350 road section experienced collapse damage, because the road did not have a channel that could drain the water according to the planned discharge. This is due to shallowing due to sediment deposition at the bottom of the channel and channel closure, resulting in quite serious damage. Jakarta Baru-Bula STA 25+213 to. 25+800 there was longitudinal cracking and crocodile skin damage, due to the road being older than the design life. The road work was planned for 5 years, but after only 1 year the damage occurred. On the Jakarta Baru-Bula STA 44+645 and 45+400 roads, road widening is being carried out from Banggoi village towards Bula city, because the road contour is very extreme.

Based on the description above, an analysis of road damage, type and level of damage will be carried out on the Banggoi - Bula Road section using the 2017 community development method. On the Banggoi-Bula Road section STA 44+645, 44+400, and 45+350. So, it is necessary to build equipment such as culverts. This is to anticipate when the rainy season is expected to prevent flooding. To determine the ESA4 and ESA5 values according to the selected design age and plan the thickness of the pavement layer on the Banggoi-Bula Road section using the 2017 Manual Pavement Design (MDP) method.

Figure 1. pictures of road damage

2. LITERATURE REVIEW

The name of the damage will describe what the damage is like. Damage cannot refer to any identified damage type. Thus, the type of damage recorded can be simplified into a combined damage system, for example the damage area is a combination of cracks, grooves and overturns. Mention the damage so that it is easy to identify, for example: grooves with alligator cracks, grooves with longitudinal cracks, etc.

To find out for certain the cause of the damage, it must be proven by visual assessment with further examination, for example; conducting surveys, physical examinations and other tests. Damage in its simple form is often easier to identify the cause [4]. Road surface damage can be caused by:

a. Excessive traffic load.
b. soil conditions and unstable soil conditions due to poor construction systems. compared to materials from pavement texture and handling errors.
c. poor drainage causes water to rise in the pavement layer due to suction or capillary forces.
d. fatigue (fatigue) due to pavement, compressive or shear forces that arise in subsoil layers, foundations, foundations and surface layers.

Types of Flexible Pavement Damage According [10] he types of damage generally vary. The types of flexible pavement damage are classified as follows:

[1] Depressed (Depression)
[2] Longitudinal/transverse cracking (longitudinal/transverse cracking).
[3] Alligator crack

2.1 Density

The difference in PCI calculations for asphalt and concrete pavement sample units lies in the method of calculating damage density. Density is the percentage of the total area or length of a type of damage to the total area or length of the slope being measured, which can be in ft2 or m2. Thus, the damage density on asphalt pavement is expressed by the equation:

$$(\text{density})\ (\%) = (Ad\ ) / As \times 100 \quad (1)$$

$$(\text{density})\ (\%) = Ld / As \times 100 \quad (2)$$

For each sample unit.
PCI value After the CDV is obtained, the PCI for each sample unit is calculated using the equation:

$$PCIs = 100 - CDV \quad (3)$$

With PCIs = PCI for each sample unit or research unit, and CDV is the CDV of each sample unit. The overall pavement PCI value on a particular road section is:

$$PCIf = \sum \frac{PCIs}{N} \quad (4)$$

2.2 Debit Plan

To calculate the planned debit the author uses the rational method, with the following formula:

$$Qr = \frac{1}{3,6} \text{ x } C \text{ x } I \text{ x } A \quad (5)$$

The calculations for masonry culverts are as follows. [3].
Channel dimensions

$$A = \frac{Q}{V} \quad (6)$$

2.3 Flexible Pavement Planning Procedures Using the 2017 Manual Pavement Design (MDP) Method.

The procedure for planning flexible pavement to achieve maximum technical and economically optimal results is as follows: [1].
Determine the life of the plan
The design life of the pavement is a measure of mass in years from the time the road is opened to traffic until the road structure needs to be repaired (pavement is required). Throughout the life of the project, pavement maintenance is still necessary and must continue to be carried out, such as non-structural surfaces that function as a wear-resistant layer. The design age of flexible pavement for new roads is usually set at 20 years or even 10 years is sufficient, whereas for road rehabilitation the design age is 10 years.

1. Determine the ESA4 and ESA5 values according to the selected plan age.

Pavement thickness planning is based on ESA values to the power of 4 and 5 depending on the damage model and design method used. Use appropriate ESA values as input in the planning process. Grade 4 is used for flexible pavement planning based on the Pt T-01-2002-B Flexible Pavement Thickness Planning Guidelines. Power 5 is used for soft pavement design (concerned with the yield coefficient of asphalt concrete according to experimental and mechanical design methods), including curve-based layer thickness planning for fatigue cracking.

3. METHODOLOGY

3.1 Lokasi Penelitian

The research location was carried out on the Banggoi-Jakarta Baru STA 45+350, Jakarta Baru-Bula STA 25+213 to 213 roads. 25+800 and STA 44+645, 45+350 Eastern Seram Regency. As shown in figure 2.

Figure 2. Research location

3.2 Data collection and analysis

In general, the research methods carried out include identification of problems and objectives, literature study, the data collected is divided into: (1) primary data, documentation

of road damage, and (2) secondary data, namely rainfall data, LHR data, CBR data.

The data collection technique is carried out using the observation method, namely by conducting a survey at the research location, and the literature method, namely the method of collecting, identifying, processing written data and working methods that can be carried out. In this research, there is an analysis method used to determine road damage, culverts and flexible pavement thickness, namely:

1. Determine road damage using the 2017 PCI Method.
   a. Determining the Deduct Value
   b. Calculating the PCI Value
2. Culvert Planning.
   a. Calculate bending compressive strength
   b. Calculate the flow coefficient
   c. Concentration Time
   d. Hydrological Analysis
3. Determine the thickness of flexible pavement using the2017 Manual Pavement Design (MDP) Method.
   a.Determine the life of the plan
   b.Determine the ESA4 and/or ESA5 values 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 bearing capacity
   e. Determine the pavement foundation structure
   f. Determine the pavement structure that meets the requirements from design chart 3 or other appropriate design chart

4. RESULT AND DISCUSSION

4.1 Road Damage Conditions

Based on the results of a survey of existing pavement surface damage on the Banggoi-Bula Road section STA 45 +350 – STA 25 + 800.

1. Types of damage that occurred

The damage that occurred collapsed, lengthwise cracked, cracked crocodile skin. To make it easier to find out each damage on the Banggoi-Bula Road section, the damage is divided into 3 segments as in Table 1:

Table 1. Damage Type for each segment

Segmen	STA	Damage Length (m)	Damage widtgh (m)	Area (m^2)	Damage Type
1	45+350	1,2	0,60	0,72	Collapsed
2	25+213	8	0,02	0,16	Cracked Crocodile skin
2	25+225	8	0,01	0,08	Longitudinal crack
2	25+250	11	0,02	0,22	Cracked Crocodile skin
2	25+275	11	0,01	0,11	Longitudinal crack

2. Damage Presentation

Density calculations to investigate the results are as shown in table 2

Segment I (STA 43 + 350)

Type of damage = Collapse
Type of damage area (Ad) = 0.72 m2
Road width = 4.5 m
Segment length = 0.11 km
Damage area formula (As) = L x L= 4.50 m x 11 m2 = 49.5 m2

Density formula = $\frac{Ad}{As}\ x\ 100\ \%\ = \frac{0,72}{49,5}$ x 100 % = 0,0145 %

From the results of calculating the percentage of damage to the 3 segments, it is obtained:
Damage due to subsidence of 0.014%
Damage due to Longitudinal Cracks of 0.814%
Damage due to cracking of crocodile skin is 1.402%
For segments II and III can be seen in Table 2.

3. Deduct Value (Deduction Value)

Calculation results for Deduct value for each segment From Figure 2, the subsidence with a density value of 0.014% with the level of subsidence or moderate damage results in a deduct value of 10%.

After reviewing the condition of the road pavement surface using the Pavement Condotion Index (PCI) method, the PCI value for each segment was obtained. for the sample that shows the results of the road pavement conditions that occur on the Jakarta Baru-Bula Road section starting from STA 43+350 – STA 25+800 after averaging, the PCI value in segment 1 is 20%. The level of damage is very bad (very poor), The PCI segment 2 value is 53%. The level of moderate damage (fair), and the PCI segment 3 value is 47%. The level of moderate damage (fair).

4.2 Culvert Planning

Planning for culverts on the Banggoi-Bula Road section was carried out as an effort to prevent waterlogging on the road body which resulted in damage to the road section.

1. Hydrological Analysis

Hydrological analysis is an analysis of maximum rainfall based on rainfall data for the last 10 years which can be seen in the table below.

Table 2. Maximum daily rainfall data

No	Year	Ch Maximum
1	2013	24
2	2014	114
3	2015	101
4	2016	66
5	2017	105
6	2018	139
7	2019	180
8	2020	235
9	2021	123
10	2022	116

4.2.1 Selection of Design Rainfall Method

To determine the appropriate design rainfall method, of the four methods that are often used, namely the normal distribution method, log normal, gumbel, and log person type III, statistical parameters are first calculated from which it will be concluded which method is appropriate. The following is a table of statistical parameter calculation results.

Calculation of statistical parameters

[1] Average value

$$\bar{X} = \frac{\sum Xi}{n} = \frac{1203}{10} = 120,3$$

[2] Deviation standard

$$Sd = \sqrt{\frac{\sum(Xi-\overline{Xr})^2}{n-1}} = \sqrt{\frac{934.984,22}{10-1}} = 305,77$$

[3] Coefficient of variation

$$Cv = \frac{Sd}{\bar{X}} = \frac{305,77}{107,35} = 2,848$$

[4] Coefficient of skewness

$$Cs = \frac{(\sum(Xi-\overline{Xr})^3}{(n-1)(n-2)Sd^3} = \frac{10\ (-906.330,52)}{(10-1)(10-2)305,77^3} = -2,3031$$

[5] Kurtosis coefficient

$$Ck = \frac{\sum(Xi-\overline{Xr})^4}{(n-1)(n-2)(n-3)Sd^4} = \frac{10\ (\ 880.033,55)}{(10-1)(10-2)(10-3)305,77^4}$$

= 691.850,27

4.2.2 Channel Discharge

Determining the Area of the Water Catchment Area

- Area of Asphalt Road A1 = (4.5/2)m x 400 m = 900 m2.
- Road shoulder area A2 = 1 m x 400 m = 400 m2.
- Exterior area of the road A3 = 500 m x 400 m = 200.000 m^2

A = A1 + A2 + A3

= 900 + 400 + 200.000

= 201.300 m^2.

= 0,2013 km^2.

4.2.3 C coefficient

- Flow Coefficient of Asphalt Road section (C1) = 0.70
- Drainage coefficient for the road shoulder for fine-grained soil (C2) = 0.60
- Outer side drainage coefficient (C3) = 0.40

$$C = \frac{C1.A1+C2.A2+C3.A3}{A1+A2+A3} = \frac{(0,70.900)+(0,60.400)+(0,40.200.000)}{900+400+200.000}$$

= 0,401739

4.2.4 Calculation of planned debit

$Q = 0,278\ x\ C\ x\ I\ x\ A$

$= 0,278\ x\ 0,401739\ x\ 178,756\ mm/jam\ x\ 0,2013\ km^2$

= 4,0187 m/detik

4.2.5 Channel dimensions

The dimensions of the planned channel are rectangular with stone masonry.

$A = \frac{Q}{V} = \frac{4,0187}{1,5} = 2,67 \rightarrow 2,70$ m^2

Taken b = 1,5 m

A = b x h

$h = \frac{A}{b} = \frac{2,70}{1,5} = 1,8$ m

Speed control:

$$V = \frac{Q}{A} = \frac{4,0187}{2,70}$$

$= 1,48\ m/dt \rightarrow 1,5\ m/dt$ (Ok)

P = 2(b + h) = 2(1,5 + 1,8) = 6,6 m

$R = \frac{A}{P} = \frac{2,70}{6,6} = 0,409\ m$

$V_{gorong} = K.R^{2/3}.(I_{gorong})^{1/2} \rightarrow I_{gorong}$

$$= \left[\frac{V}{K\ .\ R^{\frac{2}{3}}}\right]^2 = \left[\frac{1,5}{40\ .\ 0,409^{\frac{2}{3}}}\right]^2 = 0,45$$

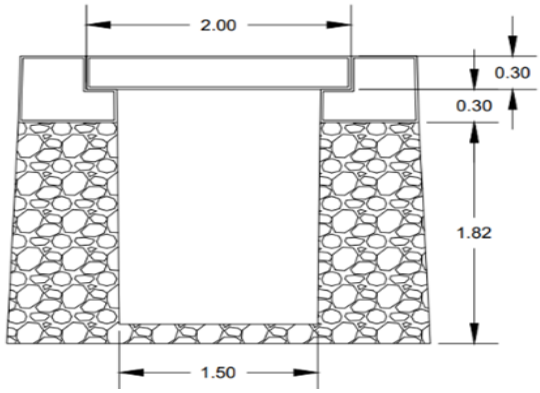

Figure 3. Culvert channel dimensions

4.3 Pavement Thickness Analysis

Pavement thickness analysis data

Type of road planned = class III C (Collector) village road
Pavement thickness = 2 lanes in 2 directions
Pavement type = Flexible pavement
Soil CBR value = 10.7%.
Average daily traffic data (LHR) = LHR data carried out with retrieve data at the department Seram Regency transportation Eastern Seram 2022

4.3.1 Calculate the ESA5 value

Average daily traffic The average daily traffic data used is data on vehicles crossing the Banggoi-Bula road section, along with a table of traffic volume by vehicle class taken from the transportation department.

Table 4 Traffic data for the Bula-Banggoi road section

No	Transportation Type	EMP	Vehicle	SMP	%
1	Motorcycle	0,5	469	234,5	35,26315789
2	Four Wheels	1,0	693	693,0	52,10526316
3	Six Wheels	1,3	168	609,7	12,63157895
Jumlah			1330	1537,2	100

From vehicle results taken from the transportation service, LHR data for 3 types of vehicles for the observation year was obtained which then became a reference (2023) in calculating LHRT for 2025 (starting year). The number of vehicles passing through the observation post was 1330 or the equivalent of 1537.2 pcu with vehicle descriptions: two-wheeled, four-wheeled, six-wheeled each being 234.5 pcu; 693.0 junior high school; 609.7 junior high school. The type of vehicle (group 2) dominates daily traffic, namely 693 vehicles or 52.10%, followed by (group 3), namely 469 vehicles or 12.63%.

4.3.2 Calculation of ESA5 Value

In pavement design, traffic loads are converted to standard load (ESA) using the Equivalent Load Factor (Vehicle Damage Factor). The EAS5 value can be calculated using each commercial vehicle and as an example a six-wheeled vehicle is taken:

$ESA5 = LHR \times VDF \times 365 \times DD \times DL \times R$

= 168 x 3.0 x 365 x 0.50x 0.80 x 10.46

= 769,688.64

From the FFF1 pavement structure table with a cumulative 20-year axle load on the design lane (106 ESA5) < 2 million, the thickness of the pavement layer that will be used in planning the Banggo-Bula road section is obtained, which can be seen in Figure 4 as follows:

AC-WC	= 40 mm
AC-BC	= 60 mm
AC-Base	= 0 mm
LPA Kelas A	= 400 mm

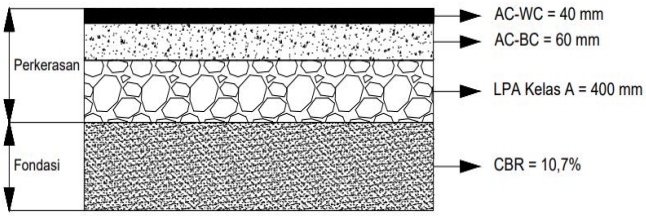

Figure 4. Sketch of the Banggoi-Bula Road pavement structure design

5 CONCLUSIONS

From the results of the analysis and calculations it can be concluded that:

The types of damage on the Banggoi-Bula Road section are sinking, longitudinal cracks and cracked crocodile skin. on the Jakarta Baru-Bula Road section starting from STA 43+350 – STA 25+800 after averaging segment 1 at 20%. Damage level is very bad (very bad), PCI segment 2 value is 53%. Moderate damage level (fair), and the PCI segment 3 value is 47%. The level of damage is moderate (fair), the level of damage is poor so that appropriate handling is based on the 2017 Bina Marga method, which is included in the regular maintenance program.

From the analysis of the results of the culvert channel dimensions at STA 44+645, 45+400, and 45+350, it was found that the channel dimensions were 1.5 m/sec, and the discharge was 4.0187 m/sec, h = 1.8 m, b = 1.5 m.

The results obtained from the analysis of the flexible pavement of the Banggoi-Bula Road section (STA 43+350 – STA 25+800) using the 2017 manual pavement design method (MDP 2017) were ESA5 769,688.64 or 0.76 million.

From the ESA5 results, it was found that the AC-WC surface layer thickness was 40 mm, the AC-BC layer thickness was 60 mm, and the thickness of the A foundation layer was 400 mm.

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NOMENCLATURE

Ad	Total area of pavement type for each level of damage severity
As	Total area of the sample unit
Ld	Total length of damage type for each level of damage severity
PCI_s	PCI value for each sample unit
CDV	Corrected deduction value
PCI_f	average PCI value of the entire research area
Qr	Planned debit with a return period of T years (m3/scnd)
C	Flow coefficient
I	Rainfall intensity (mm/hour)
A	Area of internal flow area (km²)
V	Flow speed in the channel (m/sec)
Q	debit plan