JURNAL TEKNIK SIPIL DAN LINGKUNGAN| EISSN:2549-1407
https://jurnal.ipb.ac.id/index.php/jsil

Vol. 10 No. 01 April 2025
DOI: 10.29244/jsil.10.1.97-106

Mapping of Road Pavement Conditions on the Cikampak Cicadas to the Segog Pamijahan Road Section

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Abstract: Roads are one of the land transportation infrastructures that have a vital role in supporting community activities. Road damage is often encountered in various places. If left unchecked, handling road damage will cost a lot. The purpose of this study is to identify the type and extent of damage from road pavement and drainage in the study area, as well as determine handling recommendations for road pavement using the Bina Marga method. The method used is the Bina Marga method and the main output of this method is the value of the Priority Order (UP) and the recommendation for handling the observed road. The results of the study showed that the most common type of damage encountered at the study site was elongated cracks with a total area of 582.44m^2, and lateral cracks were damages with the smallest total area, which was 6.27 m^2. The value of road condition obtained from summing the number of damage in each segment showed that the condition value of 7 was mostly owned by the road segments at the research site, namely 18 segments, while the condition values 3 and 6 were only owned by 1 segment. Recommendations for handling the east side drainage were obtained as a result that 27 segments require routine maintenance, 18 segments require periodic maintenance and 10 segments require addition to the drainage system. The drainage on the west side was obtained as a result of 35 road segments requiring routine maintenance, 14 road segments requiring periodic maintenance and 6 road segments requiring addition to the drainage system. The recommendations for handling on the road were obtained as a result that 10 road segments require routine maintenance, 26 road segments require periodic maintenance and 19 road segments require improvement with the required handling costs of Rp 39,857,105, Rp 302,529,219 and Rp 1,719,020,425 respectively.

Submitted : 23 Oct 2024
Revised: 05 Dec 2024
Accepted : 17 Apr 2025

Keywords: Road; road damage; drainage; maintenance; BOQ

1. Background

A road is all parts of a road, including complementary buildings and their equipment intended for general traffic, which are located at ground level, above ground level, below ground and/or water level, and above water level, except for rail roads and cable roads [1]. As one of the land transportation infrastructures, roads have a vital role in relation to the smooth activities of the surrounding community [2]. In more detail, there is a positive and significant influence between the good quality of road infrastructure and the economic development of the surrounding area. In addition, the quality of road infrastructure also has a positive and significant influence on the social benefits that can be received in the regionin the vicinity [3]. This will certainly go well if the road conditions are in good condition. On the other hand, poor road conditions due to road damage can result in hampered community activities in the surrounding area [4].

Road damage is a serious problem that needs to be addressed immediately. Based on BPS data (2023), the total length of roads in Indonesia reaches 548,366 km. The percentage of good, moderate, damaged, and severely damaged road conditions in a row is 43.34%; 24,06%; 14,25%; and damaged condition 18.35% [5]. Based on this data, it can be seen that the total percentage of roads with damaged and severely damaged conditions is 32.60% or 178,253 km long. Special attention is needed to road damage to reduce potential losses [6].

Road damage is grouped into two types based on their function, namely functional damage and structural damage. Functional damage is damage that occurs to the road surface layer and can cause a reduced level of safety and comfort when crossed by vehicles. Structural damage is damage that occurs to the road structure so that the road is unable to withstand the load of traffic working on it [7]. The forms of road damage have various types. Structural damage can be in the form of cracks, deformation, surface defects, and a decrease in the former utility planting (utility cut depression). Functional damage can be in the form of holes, hair cracking, peeling of surface layer grains, and *bleeding* [8].

The cause of road damage can be caused by various factors, one of which is excessive repetitive traffic load (*overload*) [9]. A road with a low traffic volume does not mean that it will not be damaged, because there are weather and environmental factors that can cause damage to the road [10]. Other factors that can affect road damage are weak maintenance, improper planning, imprecise quality of implementation, and lack of evaluation of the quality of a construction [8]. Therefore, road maintenance efforts are mandatory [11]. On the other hand, the budget available in one budget year is very limited, so the use of the budget is expected to be right on target and prioritize roads with a higher level of damage compared to other road sections.

The use of Geographic Information Systems (GIS) in the problem of road damage is a step that can be taken related to optimal road maintenance methods. The integration of the general operations of the database with the special visualization and analysis advantages of mapping can be done with the help of Geographic Information Systems (GIS) [12]. The method of assessing road damage that will be used in this study is bina marga. The output of the method used this time will be visualized into a map with the help of the Geographic Information System (GIS). Visual assessment of the condition of road pavement was carried out on the Cikampak Cicadas Highway to the Segog Pamijahan Road Section. This road section connects Ciampea Udik Village, Gunung Bunder 1 and Gunung Bunder 2 to the Leuwiliang – Bogor Highway which is the National Road.

2. Method

2.1. Material

The equipment used in this study is GPS, smartphones, stationery, measuring tapes, Google Form, Traffic Counter, meters and laptops equipped with software in the form of Microsoft Excel, Microsoft Word, Google Earth, ArcGIS. The material used in this study is the Procedure for the Preparation of the City Road Maintenance Program No. 018/T/BNKT/1990 [13].

2.2. Procedure

2.2.1. Assess Road Conditions

The assessment of road conditions at the research site uses references from the road damage assessment table in accordance with the Bina Marga method. In this method, there are several tables used to assess the number of road damage based on the type and dimension of existing road damage. The types of damage that are visually assessed are surface roughness, holes, patches, cracks, grooves and sinks. After assessing the damage to the road, the total number of damage in each segment will be classified into the value of road condition, the following is a classification table of the value of road condition based on the number of damage obtained presented in **Table 1**.

Table 1 Assess Road Conditions [13]

Damage Figures	Condition value
26 – 29	9
22 – 25	8
19 – 21	7
16 – 18	6
13 – 15	5
10 – 12	4
7 – 9	3
4 – 6	2
0 – 3	1

2.2.2. Traffic Class

Average Daily Traffic (ADT) is one of the variables needed to obtain the Priority Order value of the observed road. In this study, ADT data was taken 3 days in a row at the busiest hour. Before calculating ADT in the field, it is necessary to first know the classification of vehicles based on vehicle type to determine vehicle characteristics. The following is the classification of vehicles based on IRMS presented in **Table 2**.

Table 2 Classification of vehicle characteristics by type [13]

Type	Vehicle Type	Characteristics
1	Motorcycles, Tricycles	MC
2	Sedan, *Jeep*, *Station wagon*	LV
3	Opelet, *Pick up*, kombi, and minibus	LV
4	*Pick up*, *Micro* truck, Delivery Car	LV
5a	Small Bus	HV
5b	Big Bus	HV
6a	2-axis light truck	HV
6b	2-axle heavy truck	HV
7a	Truk 3 sumbu	HV
7b	Truk gandeng	HV
7c	Articulated trucks	HV
8	Non-motorized vehicles	UM

The classification of the vehicle needs to be known first, because the classification of the vehicle determines the characteristics of the vehicle. Based on Table 2, there are 8 class groups and 4 vehicle characteristics. These characteristics are MC (*Motor Cycle*), LV (*Light Vehicle*), HV (*Height Vehicle*) and UM (Non-motorized vehicle). The characteristics of the vehicle will determine the PCE (Passenger Car Equivalence) value, where the EMP value of MC, LV, HV and UM is 0.4 consecutively; 1; 1.3 and 0. The following calculation is used to determine the ADT that uses data on many vehicles in the PCU unit (Passenger Car Unit) which is presented in **Equation (1-2)**.

$$pcu = pce\ x\ vehicles \quad \text{..... (1)}$$

With, pcu : passenger car unit
pce : passenger car equivalent

$$ADT = \frac{traffic\ vehicles}{duration} \quad \text{..... (2)}$$

with,
ADT : Average Daily Traffic

After the ADT value is obtained, the road class is determined based on the reference in **Table 3**.

Table 3 Traffic classes based on ADT[13]

Traffic Class	ADT (PCU/day)
0	< 20
1	20 – 50
2	50 – 200
3	200 – 500
4	500 – 2000
5	2000 – 5000
6	5000 – 20000
7	20000 – 50000
8	> 50000

2.2.3. Priority Order Values

The priority order value is *the output* of the assessment of road damage conditions using the Bina Marga method, where this priority order will provide information regarding handling recommendations on the observed road segment and which road segments need immediate road maintenance/improvement. The Priority Order value of each segment is determined using **Equation (3)**.

$$Priority\ Order = 17 - (ADT\ Class + Condition\ value) \quad \text{.....(3)}$$

The following are recommendations for actions that need to be taken based on the Priority Order (UP) value of the road segment.

Priority Order (UP) value 0 – 3, roads are included in the improvement category
Priority Order Value (UP) 4 – 6, roads are included in periodic maintenance programs
Priority Order (UP) value > 6, roads included in routine maintenance program

2.2.3. BOQ Calculation

The calculation of the BOQ is carried out on the road priority handling plan to be carried out. The priority order is the *output* of the assessment of road damage conditions generated based on the calculation of the priority order value.

3. Result and Discussion

3.1. General Circumstances of the Research Location

The Cikampak Cicadas Highway Section and the Bojong Rangkas – Cicadas Road Section are roads that are access for Ciampea Udik Village, Gunung Bunder 1 and Gunung Bunder 2 to the Leuwiliang – Bogor Highway which is the National Road. These two roads themselves have the status of local roads. In addition to being a link for 3 villages to the national road, these two roads are also alternative routes for tourists and climbers who want to go to the Mount Halimun – Salak National Park Area. This road section includes a flexible pavement type road that uses asphalt as a binding material.

The two observed road sections have a total length of 5,535 m, with varying widths, ranging from a range of 415 m to 530 m. The assessment of the condition of the pavement and drainage system is

carried out visually referring to the table in the Bina Marga method. The observed road section is divided into 55 segments, of which the length of each segment is 100 m. The starting point of observation is labeled STA 0+000 and the end point of observation is labeled STA 5+535.

3.2. Traffic Class

Average Daily Traffic (ADT) data is required to obtain the traffic class at the study site. The ADT calculation in this study was carried out for 3 consecutive days, starting from Thursday, May 9, 2024 to Saturday, May 11, 2024. The ADT data obtained are presented in **Table 4**.

Tabel 4 Traffic Volume Data

Day	Karakteristik Kendaraan			q_{JP} (PCU/hour)
	MC (0,4)	LV (1)	HV (1,3)	
Thursday	1679	244	23	945.5
Friday	1156	163	18	648.8
Saturday	1465	176	7	771.1

Based on the table above, the qjp (traffic flow of planning hours) obtained during observation at the research site was 2,365.4 PCU. The qjp value is obtained by multiplying the PCE (Passenger Car Equivalence) value of each vehicle class by the number of vehicles calculated. The PCE value is obtained from the 2023 Indonesian Road Capacity Guidelines. Furthermore, the ADT value obtained based on Table 4 is 7,885 PCU/day. Based on the ADT value obtained, the traffic class at the research site is class 6.

3.3. Road Damage

The road damage survey was carried out visually by tracing the observed road sections from segment 1 to segment 56. When conducting an assessment, each damage is recorded in its type and dimensions, for further assessment based on the table in the Bina Marga method. The following are presented in **Figure 2** the types and total area of each damage at the research site in m^2 units.

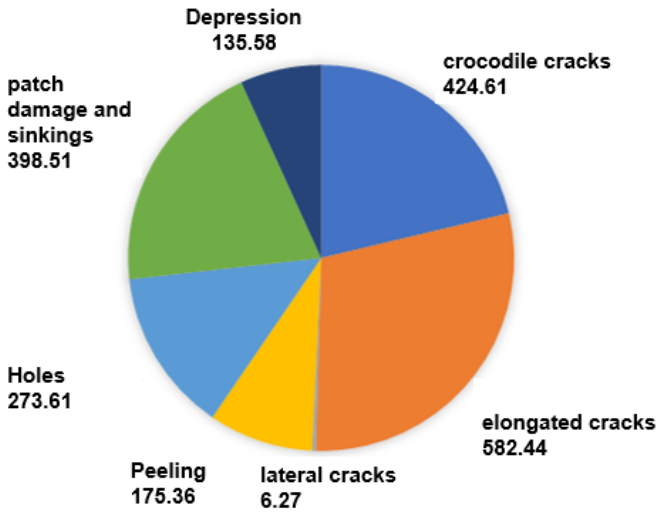
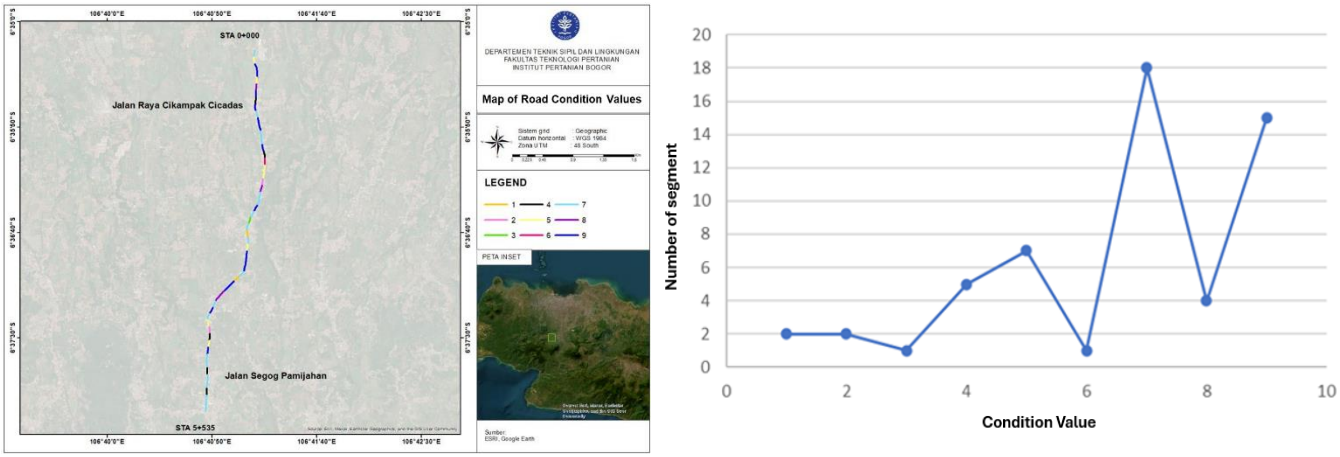


Figure 2 Comparison of the extent of damage types in units m^2

Based on **Figure 2**, it can be known what damage is and what is the total area of each type of damage. There are 7 types of damage found at the research site, namely crocodile cracks, elongated

cracks, lateral cracks, peeling, holes, patch damage and sinkings. Of the 7 types of damage found, elongated cracks are the ones with the highest total area of 582.44m^2, and lateral cracks are the damage with the smallest total area of 6.27 m^2. Elongated cracks can be encountered a lot because this type of damage is directly affected by traffic factors, where elongated cracks will arise along the vehicle's trajectory as a form of fatigue from the road surface against the vehicle's load. While lateral cracks are less numerous, as a result of this type of damage is not predominantly due to vehicle loads, but is more dominant due to temperature factors related to thermal stress and lack of compaction in the pavement layer [14].

After recording the type, dimensions and extent of the existing damage, then a damage assessment is carried out based on the Bina Marga method. This assessment uses 5 parameters, namely the number of the type, width, area, and depth of damage and the number of the length of the sinking. The assessment was carried out in 55 segments and from these assessments the total number of damages in each segment was obtained. This figure is obtained by summing the damage number of each type of damage that exists in the segment. Furthermore, the damage figures for each segment are compared with Table 1 to obtain the value of road conditions. The following in **Figure 3** is presented a visualization in the form of a map of the road condition value of the 55 segments surveyed and a graph describing the road segments reviewed from the road condition value.



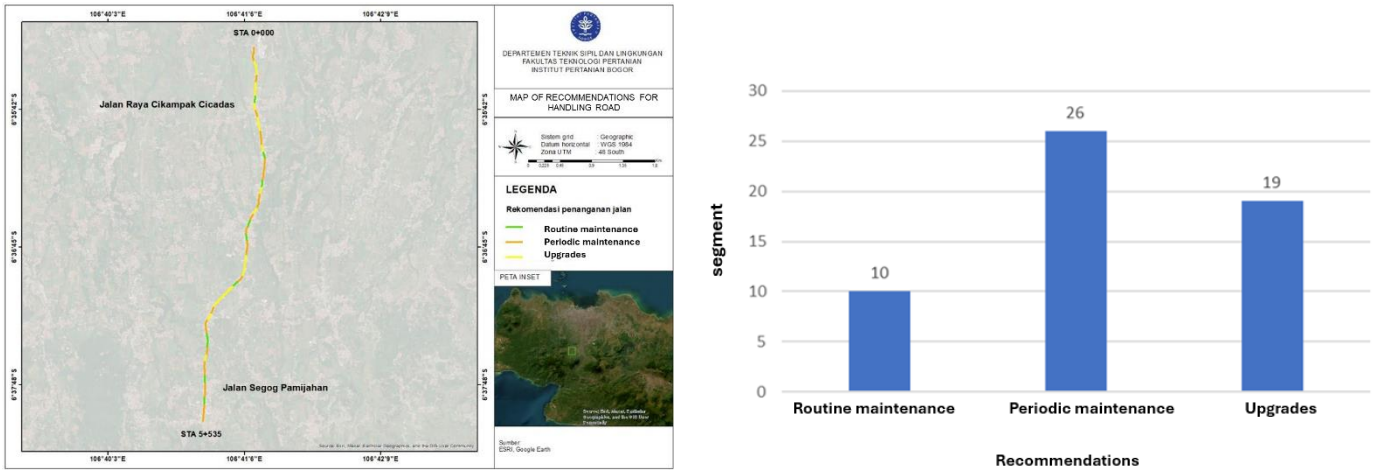
(a) (b)

Figure 3 Map of road condition values (a) along with graphs based on road condition values (b)

Based on Figure 3, it can be seen that out of the 55 road segments surveyed, as many as 18 road segments have a condition value of 7. On the contrary, there is only 1 road segment with condition values of 3 and 6. The high value of road conditions indicates that the number of damage to the road is quite severe, so it can be said that the damage to the road is quite severe, and vice versa. The value of road conditions is then used to obtain the Priority Order (UP) value for each observed road segment. This value will determine what action recommendations should be applied to the road segments in the survey. The following is presented in **Figure 4** visualization in the form of a map of handling recommendations according to the Bina Marga method of 55 segments surveyed and a bar chart that groups segments based on the type of handling.

Based on Figure 4, it is known that there are 3 types of handling recommendations according to the Bina Marga method, namely routine maintenance, periodic maintenance, and improvement. There are 10 road segments that require routine maintenance, 26 road segments that require periodic maintenance, and 19 road segments that require improvement. Routine maintenance includes small jobs that are routinely performed within a year. Periodic maintenance is carried out over a specific period of time which is usually more than one year. Jobs included in routine maintenance are minor repairs and surface patching. Meanwhile, the work included in periodic maintenance is local repairs in the form of

patching the entire depth and asphalt planting. The work included in the improvement is local repairs in the form of patching the entire depth, asphalt installation, and equipped with *overlays*.

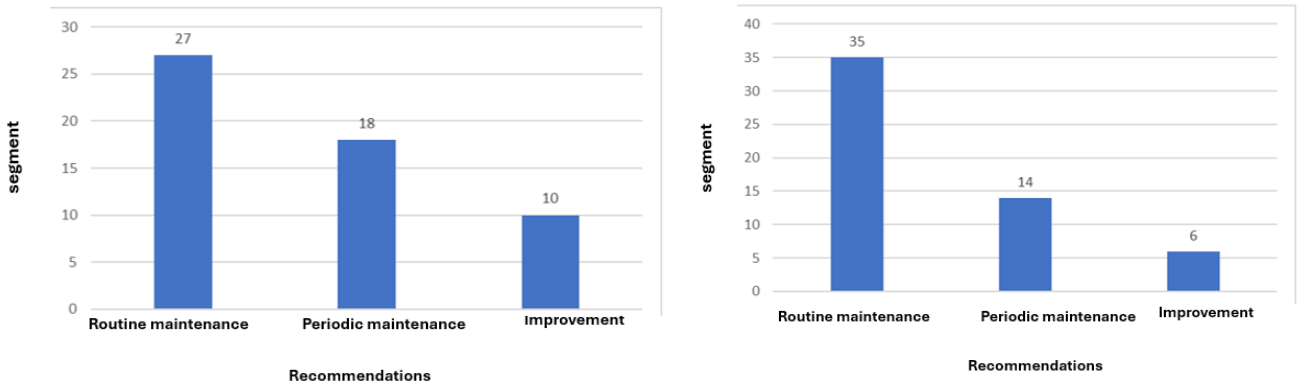


(a) (b)

Figure 4 Recommendations for handling road segments through maps (a) and bar charts (b)

3.4. Drainage Conditions

Drainage system is a series of facilities and infrastructure that aim to dispose of excess water in an area so that water does not inundate the area [15]. These are presented in **Figure 5**, where the value of drainage conditions based on the assessment carried out at the research site.



(a) (b)

Figure 5 Handling recommendations for drainage (a) east and (b) west side

Based on Figure 5, it can be seen that drainage on both sides of the road requires handling in the form of routine maintenance, periodic maintenance and improvement. On the east side of the road segment, 27 segments require routine maintenance, 18 segments require periodic maintenance and 10 segments require addition to the drainage system. On the west side of the road segment, as many as 35 road segments require routine maintenance, 14 road segments require periodic maintenance and 6 road segments require addition to their drainage system. Routine maintenance of the drainage system is needed to maintain the smooth running of the drainage system, the implementation can be in the form of cleaning vegetation and sediment in the channel. Periodic maintenance can be carried out by carrying out significant repairs to the drainage system. Addition to drainage is carried out by adding new drainage

channels on the side of the road that do not have drainage or improving the drainage structure so that runoff on the road can be immediately drained and does not cause inundation [16]. The following is presented in **Figure 6** the drainage conditions of the observed road segments visualized in the form of a map.

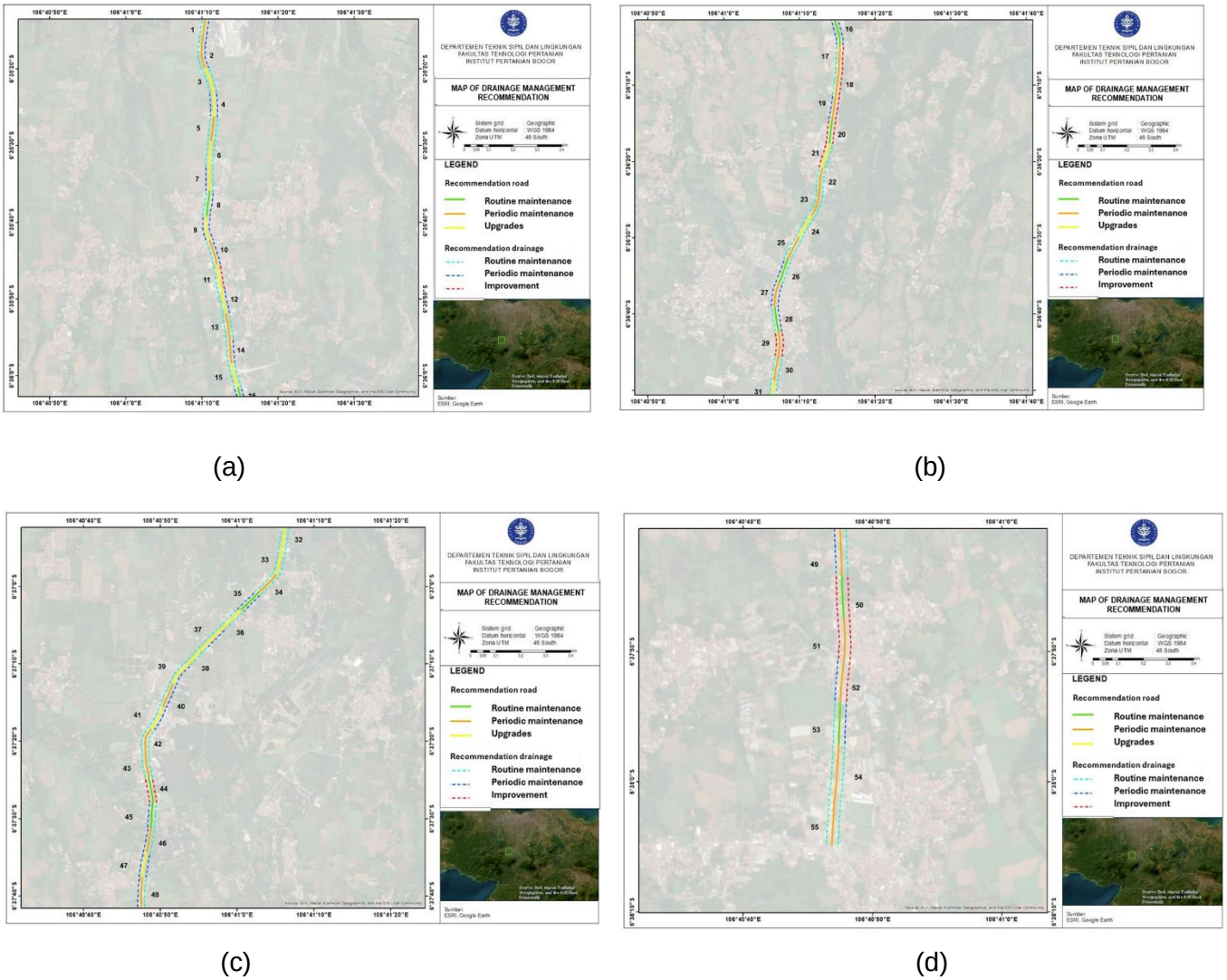


Figure 6 Drainage management recommendation map segments (a) 1 – 15, (b) 16 – 31, (c) 32 – 48, (d) 49 – 55

Based on **Figure 6**, it can be seen that segments 1 to segment 55 have drainage that requires regular maintenance, periodic maintenance and addition. Routine maintenance of drainage in this road segment can be in the form of cleaning vegetation and sediment that accumulates on the channel section. Periodic maintenance can be in the form of improvements to the drainage channel structure. Adding drainage can be done by creating new drainage channels in road segments that have severely damaged channels or even do not have drainage channels at all. Drainage maintenance should be carried out first before road maintenance is carried out to prevent the condition of the road from remaining bad even though road maintenance has been carried out due to water runoff that is not properly drained [17]. Roads that are maintained first without maintenance on drainage will result in the repair of the road being quickly damaged. Drainage that is not maintained will inhibit the flow of rainwater runoff on the road body, thus causing inundation on the road body. The inundation will infiltrate into the road pavement system, which will certainly affect the weakening of the subsoil and structure of the road pavement. The existence of

drainage on both sides of the road can help to reduce the absorption of rainwater into the road pavement [13].

3.4. BOQ

There are 3 handlings on the roads at the research site, namely routine maintenance, periodic maintenance and improvement. The actions taken for routine maintenance are partial patching and asphalt paving work. The action taken for periodic maintenance is the patching of the entire depth and asphalt paving work. The actions taken for road improvements are patching of the entire depth, asphalt laying work, and *overlaying*. The following is presented in **Table 5** of the Bill of Quantity of the handling recommendations based on the Bina Marga method.

Table 5 The Bill of Quantity based on the planned refinement

Refinement		Price (Rp)
Routine maintenance	Rp	39,857,105
Periodic maintenance	Rp	302,529,219
Upgrades	Rp	1,719,020,425

4. Conclusion

The results of the survey at the research site showed that damage data dominated by the type of elongated crack damage with a total area of 582.44 m^2 and lateral crack being the least common type of damage, with a total area of only 6.27 m^2. Recommendations for handling road segments based on the results of the study show that as many as 10 road segments require routine maintenance, 26 road segments require periodic maintenance, and 19 road segments require improvement. On the east side drainage, there are 27 segments that require routine maintenance, 18 segments require periodic maintenance and 10 segments require addition to the drainage system. On the west side, as many as 35 road segments require routine maintenance, 14 road segments require periodic maintenance and 6 road segments require addition to their drainage system. Drainage maintenance is important to be done first before carrying out road maintenance so that the life of the road maintenance results can be durable and not disturbed by the inundation factor from water. The cost needed to handle the road in the form of routine maintenance, periodic maintenance, and consecutive upgrades is Rp 39,857,105, IDR 302,529,219 and IDR 1,719,020,425.

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