Timor-Leste Journal of Engineering and Science

Vol.4, Issue 1, pp 45-53, 2023
Available online at: http://tljes.org/index.php/tljes/data

The Road Infrastructure Damage Assessment in East Penfui Village, Kupang District

Yohanes Nahak, Krisantus Satrio Wibowo Pedo
Civil Engineering Study Program, Widya Mandira Catholic Univeristy, Kupang, Indonesia
Email: krisantuspedo@unwira.ac.id, jhonnahak29@gmail.com

ABSTRACT

The development and activities of community transportation are hampered by the condition of the damaged roads, notably in the surrounding area of East Penfui Village, Central Kupang sub-district, and Kupang district. The purpose of this study is to determine the severity of East Penfui Village's road infrastructure damage. The Surface Distress Index (SDI) approach is utilized in the research to measure the severity of road damage. Primary data collection was carried out according to the construction and building manual on road condition surveys for routine maintenance 001-01/M/BM/2011 issued by Bina Marga. The study's findings showed that sections 1, 3, and 4 of the roads had moderate to good road conditions, but part 2 had badly deteriorated conditions. Grain damage makes up 39% of all road damage types, followed by edge cracks (24%), elongated cracks (20%), and potholes (17%). It is recommended that regular maintenance must be done on parts 1, 3, and 4 of the roads, and section 2 of the roads has to be reconstructed.

Keywords: Road Damage, SDI, East Penfui

Received January 16, 2023; Revised March 20, 2023; Accepted May 8, 2023

1. Introduction

Roads are a crucial piece of infrastructure for maintaining communal life. According to the function of the road network, the road network plays a role in regional development at the national, regional, and district/city levels in macro-infrastructure. The road pavement layer frequently sustains damage or fails earlier than the target design age as the design life progresses. There is growing concern over the road damage that occurred on a number of routes in the district area. This is due to the fact that the road's condition, which was first only mildly harmed, has been neglected and is currently deteriorating. Such road conditions will inevitably interrupt traffic flow operations and are even quite likely to result in traffic accidents.

Pavement damage can be seen from functional and structural failures. Because the road function cannot operate as intended and inconveniently affects road users, functional failure itself arises. Damage to one or more pavement structure components frequently leads to structural failure. The main causes are unstable subgrade, excessive traffic loads, surface fatigue, non-existent drainage systems, poor materials, and the influence of the surrounding environmental conditions. (Sukirman, 2010).

As a result of road damage, community transportation operations are hampered in terms of comfort and safety as well as development (Arianto, Suprapto and Syafi'i, 2018), especially in the area of East Penfui Village, Central Kupang sub-district, Kupang district. The author considers that it's crucial to look for and document any additional damage after noticing how poorly maintained the road infrastructure is in several areas in this rural region. The purpose of this study is to use the Surface Distress Index (SDI) approach to identify road damage so that the best treatment strategy may be determined for each damage type.

The SDI method has been widely used in determining the level of road damage. Previous research conducted in West Jakarta showed that there was no significant difference between the results of road condition levels using the PCI (Pavement Condition Index) method and the SDI with a difference of about 6.5%, but the SDI method has more advantages in determining the level of damage to asphalt and soil roads (Amelia Setiaputri *et al.*, 2021). According to the findings of additional studies conducted in the East Java Province, the SDI method's level of road damage can be combined with the IRI (International Roughness Index) value to determine maintenance recommendations, but the SDI method's results are preferable because they are more accurate in terms of data collection than those from the IRI method (Arianto, Suprapto and Syafi'i, 2018). According to the findings of a different study, the SDI approach was used to determine how much it would cost to maintain one of the roads in Sukabumi District. According to researchers, the SDI approach can serve as a model for maintenance operations (Muhammad Yusup, Tahadjudin and Kartika, 2019).

Because the SDI method is one of the results of the Road Condition Survey (RCS), which is frequently carried out by the public works service in order to strengthen the road data base, the researchers who conducted research on the analysis

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of road conditions in the province of East Nusa Tenggara chose to use this method (Nainggolan *et al.*, 2022).
The SDI method is appropriate for use in this research to assess road damage because it has been utilized by numerous researchers to analyze the condition of roads.

2. Literature Review

2.1. Road Infrastructure

A road is defined as a land transportation infrastructure by Indonesian Law No. 38 of 2004 regarding Roads, which also covers any supplemental structures and machinery utilized in traffic activities on land, in water, underground, and/or under water. According to its function, the road is divided into 4 namely:

a. Arterial Road
Public roads that serve as the primary means of transportation. They are characterized by huge travel lengths, high average speeds, and effectively limited access roads. (Pemerintah Republik Indonesia, 2004)

b. Collector roads
Public roads that are used for collecting and distribution of goods and have characteristics such as moderate traffic, a moderate average speed, and few access roads (Pemerintah Republik Indonesia, 2004).

c. Local roads
Public roads that are used to serve local transportation with short-distance travel characteristics, low average speeds (Pemerintah Republik Indonesia, 2004).

d. Neighborhood roads.
Public roads that are used to serve environmental transportation with the characteristic of short distance travel, with a low average speed (Pemerintah Republik Indonesia, 2004).

2.2. Road Sections

In Indonesia, the sections of the roads are divided into three categories based on the area, including the Road Benefit Space, which comprises of the road body, side channels, and traffic-safety thresholds, Road Monitoring Room, which is located outside the road property space and whose usage is regulated by road administration so as not to disrupt traffic operations, is part of the road owned area and is meant to widen the road benefit space.

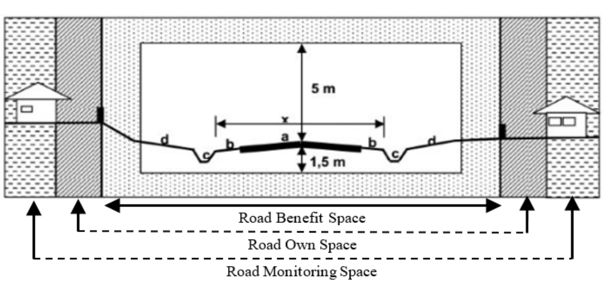

Figure 1. Road Sections
(Source: Pemerintah Republik Indonesia, 2006)

2.3. Road Damage Survey

A survey of pavement damage examines the combination of different types of damage, the degree of the damage, the location, and the scope of the damage. In this case, each person or group conducting the survey needs to be consistent and precise in all of their details. (Yudaningrum and Ikhwanudin, 2017).

The purpose of a pavement damage survey is to determine the type of damage to the pavement, how to overcome it and obtain an estimated cost calculation for repairs and maintenance. This information is very useful for the government in allocating funds for maintenance. This survey work is very important for the government and/or individuals who wish to obtain road damage data. This road pavement damage survey is helpful for identifying the causes of pavement damage as well as for selecting the appropriate handling and maintenance procedures (Setiadji, Supriyono and Purwanto, 2019).

There are several ways to ensure that road section conditions are compliant with database information. Authorities throughout the world use a variety of methods to collect data, including expensive instruments or the naked eye (Salvatore Cafiso and Battiato, 2006). In Indonesia, road damage data was obtained from road condition surveys based on construction manuals and buildings regarding road condition surveys for routine maintenance 001-01/M/BM/2011 issued by Bina Marga with the survey variables carried out as shown in Figure 2 below.

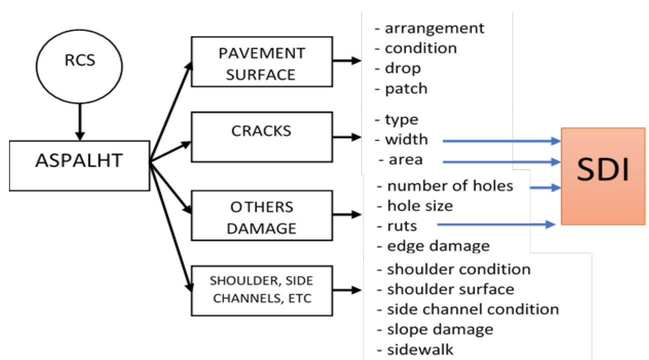

Figure 2. Asphalt Road Surface Overview
(Direktorat Jendral Bina Marga, 2011)

2.4. Road Pavement Structural Damage

Road damage may occur for a number of reasons. There are six general reasons why pavement damage on roads might occur (Wiyono, 2009).

a. Traffic, which can be in the form of increased loads and load repetitions.

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b. Water, which can come from rainwater, poor road drainage systems, or rising water with capillary properties.
c. Pavement construction materials can be affected by material properties or management systems that are not good.
d. Climate, where the air temperature and rainfall are generally high.
e. Unstable subgrade conditions.
f. Improper compaction of topsoil.

Damaged roads may have an adverse effect on developments nearby and disrupt activity. There are two categories of damage: structural and functional damages (Sukirman, 2010). Structural damage is damage indicated by the inability of the pavement to accommodate traffic loads due to pavement failure or damage to one or more pavement components. Functional damage is damage that causes the safety and comfort of road users to be disrupted so that vehicle operating costs increase. (Sulaksono, 2001).

In evaluating road damage, there are several things that need to be determined:

a. Distress type and its causes.
b. Distress severity.
c. Distress amount.

Road damage that occurs on flexible pavement includes 19 types of damage, namely alligator cracking, edge cracking, longitudinal and transverse cracking, block cracking, slippage cracking, bleeding, bums and sags, corrugation, depression, joint reflection, lane/shoulder drop off, patching and utility cut patching, polished aggregate, potholes, railroad crossings, rutting, shoving, swell, weathering and raveling. (Shahin, 1994).

According to the road maintenance manual No: 03/MN/B/1983 issued by the Directorate General of Highways, road damage can be divided into:

a. Cracking

Cracks are divided into eight types: fine cracks, alligator cracks, edge cracks, shoulder joint and pavement cracks, lane joint cracks, widening cracks, reflection cracks, shrinkage cracks, and slippage cracks.

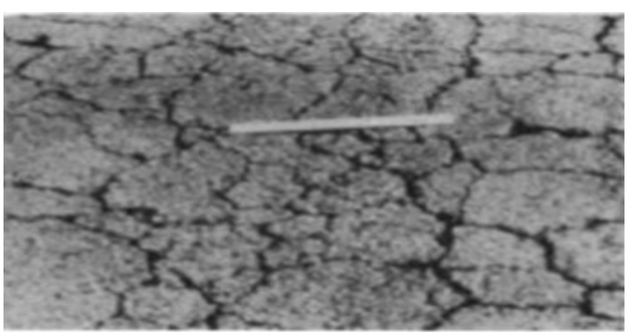

Figure 3. Example of Cracking (Alligator Cracks)

The causes of cracks range from poor pavement to poor drainage systems and unstable soil conditions. The repair process can be carried out by filling the cracks again with liquid asphalt, repairing drainage, or replacing them with new pavement.

b. Distortion

Distortion is a change in shape that can occur due to weak subgrade and a lack of compaction in the foundation layer. Distortion can be distinguished by ruts, corrugation, shoving, grade depressions, and upheaval.

Figure 4. Example of Distortion (ruts)
(Direktorat Jendral Bina Marga, 1983)

c. Disintegration

Surface defects are a type of damage that leads to chemical and mechanical damage to the pavement. Surface defects include potholes, reveling, and stripping of the surface layer. Repairs can be made by removing the old layer and filling it with new pavement mix.

Figure 5. Example of Disintegration (Pothole)
(Direktorat Jendral Bina Marga, 1983)

d. Polished Aggregates

Polish aggregates are damaged with their surface characteristics becoming smooth due to the use of round and smooth aggregates, not cubical-shaped. Repairs can be made by closing the layer using thin layer of asphalt sand or asphalt paving.

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Figure 6. Example of Polished Aggregates (Direktorat Jendral Bina Marga, 1983)

e. Bleeding

Bleeding occurs due to the use of high levels of asphalt in the mixture, which causes the surface to become smooth. The repair that can be done is to provide a cover.

Figure 7. Example of Bleeding (Direktorat Jendral Bina Marga, 1983)

f. Utility Cut Depression

Occurs due to compaction that does not meet the requirements in closing former utility plantings. Repairs can be made by disassembling and replacing the appropriate layer.

Figure 8. Example of Utility Cut Depression (Direktorat Jendral Bina Marga, 1983)

2.5. SDI (Surface Distress Index)

The road condition evaluation indicator serves as a gauge for classifying road conditions so that technical calculations for the expected road section's repair can be made.

Table 1. SDI Road Condition Assessment

Road Conditions	SDI	Maintenance Recommendation
Good	<50	Routine
Moderate	50-100	Routine/Periodically
Light Damage	100-150	Rehabilitation
Heavy Damage	>150	Reconstruction

Table 2. Crack Area Assessment

No	Crack Area Category	SDI[a] Value
1	None	-
2	<10%	5
3	10-30%	20
4	>30%	40

SDI (Surface Distress Index) is a road performance scale obtained from visual observations of road damage that occurs in the field. The advantages of using the SDI method are firstly the ease in survey techniques where the survey is carried out by direct field observation, secondly the ease in analysis because the data has been segmented, thirdly the ease in data processing. While the drawbacks in using the SDI method are that first it requires a long survey time if the roads are getting longer and secondly it still uses a manual filling system and does not yet use a computational system.

Table 3. Crack Width Assessment

Number	Crack Width Category	SDI[b] Value
1	None	-
2	Fine < 1 mm	-
3	Moderate 1-5 mm	-
4	Wide > 5 mm	Result SDI[a] x 2

There are 4 categories of damage that are used to calculate the SDI value, namely the percentage of crack area, average crack width, number of holes/km, and average rutting depth of ruts.

Table 4. Assessment of the Number of Holes

No.	Category Number of Holes	SDI[c] Value
1	None	-
2	< 10/100 m	Result SDI[b] +15
3	10-50/100 m	Result SDI[b] +75
4	>50/100 m	Result SDI[b] +225

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Table 5. Assessment of Ruts

No,	Ruts Category	X Value	SDI^d Value
1	None	-	-
2	< 1 cm	0,5	Result SDI^c + 5 x 0,5
3	1-3 cm	2	Result SDI^c + 5 x 2
4	> 3 cm	4	Result SDI^c + 5 x 4

The technique for calculating the SDI value can be seen based on the information in Tables 1 to 5. The calculation is done by determining the SDI value in Table 1 according to the results of the survey form and then the calculation results will be used sequentially for other SDI assessments. An illustration of the calculation of the SDI value can be seen in Figure 3.

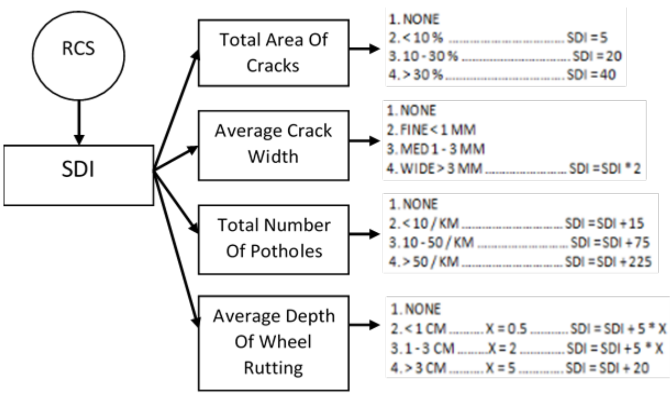

Figure 9. Asphalt Road Surface SDI Calculation
(Source: Bina Marga, 2011)

3. Research Methodology

This research was conducted in Hamlet 2, East Penfui Village in February 2023. The research method used is a quantitative method by collecting primary data in the field on 6-7 February 2023 using camera assistance, geo-tracker applications and filling out condition survey forms road. Data collection in the field was carried out by 5 surveyors, with details of 1 surveyor operating the geo-tracker application, 2 surveyors driving motorcycles and 2 surveyors filling out survey forms and operating camera.

There are 4 roads reviewed in this study, namely Section 1 (400 m long) is Jl. Simon Tafoki 1, Section 2 (211 m long) is Jl. Paulus Saba'at, Section 3 (247 m long) is Jl. Simon Tafoki 3, and Section 4 (length 175 m) is Jl. Simon Tafoki 2. In data collection, each segment is further divided into segments per 200 m.

Figure 4. Map Of Location
(Source: google maps)

The data observed in the field is in the form of an assessment of the condition of the road surface in accordance with the guidelines in guide Number SMD-03/RCS from the Directorate General of Highways Year 2011 concerning Guidelines for Road Condition Surveys based on (see figure 2). The analytical method used is the calculation of road damage conditions with SDI from Bina Marga which is calculated in stages according to the equation in Table 2-5. The results of the SDI value will then be compared with the type of assessment of road pavement conditions in Table 1. After obtaining the type of surface condition, it will be recommended the type of handling per road segment in accordance with the provisions of the road maintenance manual No: 03/MN/B/1983 issued by the Directorate General Highways.

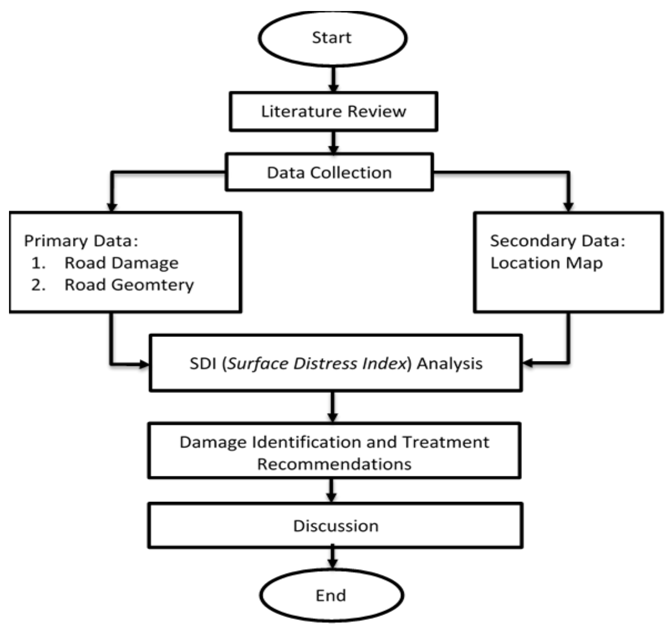

Figure 10. Research Flowchart

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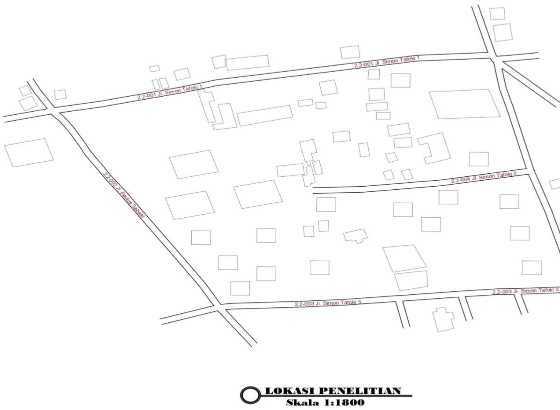

Figure 11. Research Location Map

4. Result

4.1. Survey Results

For this study, the samples consist of 4 review road segments. Land use types are schools, housing, and boarding houses. Figure 12 illustrates an example of road conditions on section 1. It can be seen that there are potholes and reveling damages on the road section. The roads also do not have sidewalks or road drainage.

Figure 12. Road Condition Section 1 (Simon Tafoki 1 Street)

Figure 13 illustrates an example of road conditions on section 2. It can be seen that there is longitudinal damage and edge cracking damage.

Figure 13. Road Condition Section 2 (Paulus Saba'at Street)

Figure 14 illustrates an example of the condition of road section 3. It can be seen that there are potholes and reveling. The roads also do not have sidewalks or road drainage.

Figure 14. Road Condition Section 3 (Simon Tafoki 3 Street)

Figure 15 illustrates an example of the condition of road section 4. It can be seen that there are potholes and cracking damages. The roads also do not have sidewalks or road drainage.

Figure 15. Road Condition Section 4 (Simon Tafoki 2 Street)

4.2. SDI Method Road Condition Results

Tables 1 through Table 5 show the calculation procedures based on the findings of a road condition survey and an analysis of the severity of road damage utilizing Bina Marga's SDI approach. The results of the calculation of road surface conditions can be seen in Table 6 to Table 9. The table's value column displays the SDI value, the condition column displays the four categories of road conditions measured by the SDI method in accordance with Table 1's provisions, and the recommendation column displays maintenance advice in light of the condition column's findings and Table 1's provisions.

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Table 6. SDI Value Section 1

Sta		SDI		
From	To	Value	Condition	Recommendation
000+000	00+200	55	Moderate	Routine Maintenance
00+200	00+400	3	Good	Routine Maintenance

Table 7. SDI Value Section 2

Sta		SDI		
From	To	Value	Condition	Recommendation
000+000	00+200	238	Heavy Damage	Reconstruction
00+200	00+211	3	Good	Routine Maintenance

Table 8. SDI Value Section 3

Sta		SDI		
From	To	Value	Condition	Recommendation
000+000	00+200	75	Moderate	Routine Maintenance
00+200	00+247	15	Good	Routine Maintenance

Table 9. SDI Value Section 4

Sta		SDI		
From	To	Value	Condition	Recommendation
000+000	00+175	15	B	Routine Maintenance

4.3. Type and Distribution of Damage According to SDI Method of Bina Marga

According to the findings of a survey carried out in East Penfui Village, potholes, longitudinal cracks, reveling, and edge cracks were the most common types of damage. The percentage of various types of road surface damage was calculated, and the results are shown on Table 10.

Table 10. Percentage of Damage Based on the Type of Damage

No	Damage Category	Area	% Damage
1	Reveling	400	39%
2	Longitudinal Cracks	211	20%
3	Edge Crack	247	24%
4	Potholes	175	17%
	Total	**1033**	**100%**

4.4. Causes and Management of Damage According to Bina Marga (1983)

Based on the filed survey and analysis, the cause and the most appropriate course of action can be determined according to the road maintenance manual No: 03/MN/B/1983 issued by the Directorate General of Highways.

a. Reveling

Causes: Poor mix of asphalt layer material, weakening of binder and/or rock, Poor compaction, because it is done during the rainy season, and Hydrophilic aggregate (aggregate easily absorbs water).

Treatment: Surface treatment using vocal chips or slurry seals for 39% of reveling damage.

Figure 16. Example of Reveling Damage on Location

b. Longitudinal Crack

Cause: There is a change in the volume of soil in the subgrade due to vertical movement and subsidence of piled up soil or movement of the embankment slope.

Treatment: Repair or Closure of cracks of 20% of the road segment area.

Figure 17. Example of Longitudinal Crack Damage on Location

c. Edge Crack

Causes: Lack of support from the lateral direction (from the road shoulder), Poor drainage, Swelling and shrinkage of the surrounding soil, the shoulder of the road drops against the pavement surface, Weak seal coat, Loss of surface adhesion to the base layer, Heavy traffic concentration on near the edge of the pavement and the existence of large trees near the edge of the pavement.

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Treatment: If the shoulder of the road does not support the pavement edge, then it is dismantled and replaced with compacted good material, if the causative factor is water, drainage must be made, surface crack closure/covering and partial patching of 24% of the road segment area must be made.

Figure 18. Example of Edge Crack Damage on Location

d. Potholes

Causes: Poor surface layer material mixture, water ingress into the foundation layer through unrepaired cracks, disintegration of the base layer due to traffic loads and removal of asphalt from the worn layer due to adhering to vehicle tires.

Treatment: Repairs on 17% of the road segment area with patching in all depths and temporary repairs by cleaning and filling the potholes using a special cold asphalt mixture for patching.

Figure 19. Example of Potholes Damage on Location

5. Conclusion

Based on the discussion above, several conclusions can be drawn, including:

a. The SDI assessment for road damage gave results for Section 1 that were moderate and good, Section 2 that were extensively damaged and good, Section 3 that were moderate and good, and Section 4 that were good.
b. Sections 1, 3, and 4 need routine maintenance to address recommendations for treating road deterioration, while Sections 2 need reconstruction/improvement.
c. Revealing damage is the most common type of damage, accounting for 39% of all damages, followed by longitudinal crack damage (20%), edge crack damage (24%), and pothole damage (17%).
d. It is recommended that the handling of road damage, namely loose grains, elongated cracks, edge cracks, and potholes be carried out in accordance with the road maintenance manual No: 03/MN/B/1983 issued by the Directorate General of Highways.

6. Limitation and Future Research

This study has several limitations that can be re-examined by other researchers. To avoid data retrieval in the field, it is advised that researchers who are going to study related subjects pay close attention to how accurately each surveyor measures the type of road damage. In order to compare the data gained, it is expected that future study will use a variety of survey and analysis methods from both Indonesia and other nations.

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