

## Types of Road Pavement Damage for Road on Peatland, A Study Case in Palangka Raya, Central Kalimantan, Indonesia

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**Abstract:** Palangka Raya has some problems about road pavement failure. The failure problems is caused several factors such as the water problems, traffic, the condition of the subgrade, climate, the material is not good and problems of compaction. The aims of this study is to classified the type of road pavement damages for road on peatland especially in Palangka Raya. The type of road damages in Palangka Raya are depressions, hair cracks, edge cracks, raveling, alligator cracks, potholes. With the variety of the damage caused inconvenience for road users. Road repairs have been done but the damage is almost as still occur because of the rain that falls on the surface of road pavement does not flow into the drainage channel in the vicinity due to the elevation of the road and the land next to the road that do not allow rainwater to flow into drainage channels lead to water flooded the edge of the road and entrance through the cracks are beginning to occur and the more severe because it is not addressed immediately.

**Keywords:** depressions, edge cracking, potholes, peatlands, ravelling.

### I. Introduction

Peatlands is not a suitable location for any roads but the needs make the roads are built on the peatland. This case has some problems to the road conditions. Some soil stabilization had done to overcome the problems but it showed some failure in the road.

In general, the highway damage can be caused by the water flow, pavement construction material, climate, unstable soil conditions and poor compaction process on layer above the subgrade.

Central Kalimantan is located at 0°45' North Latitude to 3°30' South Latitude and 111° to 116° Eastern Longitude with the area is 153,567 km<sup>2</sup>. As one of several province in Indonesia which have tropical peatlands, several roads in this province is built on the peatlands. Palangka Raya is the capital of this province. The road condition is in Table 1.1.

Table 1 Road Condition in Palangka Raya City

No.	Description	Length of road (kms)	Percentage (%)
1.	Total of Road Length	607.741	
2.	Type of Surface:		
	a. Asphalt/Concrete	358.433	58.978
	b. Agregates	3.760	0.619
	c. Soil	250.048	41.144
3.	Road Condition:		
	a. Stable:		
	- Good	109.440	18.008
	- Intermediate	192.678	31.704
	Total:	302.118	49.712
	b. Unstable:		
	- Poor	158.438	26.070
	- Very poor	147.685	24.301
	Total:	306.123	50.371

Source: Department of Civil Works City of Palangka Raya (2010)

Sukirman (1996) states that the damage to the road pavement is generally caused by: 1) Water, in the form of infiltration of rainwater, road drainage system is problematic, ground water rises due to the nature of capillarity; of ground water 2) Traffic, an increased burden and tend to be redundant and looping load; 3) Material pavement construction, material properties that do not meet standards or material processing system is not appropriate; 4) Climate for tropical countries have high rainfall and air temperature are also quite high; 5) soil conditions unstable base, for example land is essentially peat or it could be due to the implementation of the system of ground work that does not fit; 6) The process of compaction that is not good.

According to the Road Maintenance Manual DGH No: 03 / MN / B / 1983, the road pavement damage is classified into: 1) Cracking; 2) Distortion; 3) Disintegration; 4) Polished aggregate; 5) Bleeding or flushing; 6). Utility cut depression.

**Table 2 Types of Damages**

No.	Types of Damages	Descriptions
1.	Cracking	Damage occurs in the surface layer of the road, divided into 9 (nine) types of cracks are: hair cracking, alligator cracks, edge cracks, edge joint cracks, lane joint cracks, widening cracks, reflection cracks, shrinkage cracks, slippage cracks to cause varying among others could be because the soil road base is less stable, the surrounding drainage system is not good, the job execution procedure that is not good, not good paving material, which exceeds the load capacity of the road traffic and other causes.
2.	Distortion	Deformation caused by the carrying capacity of the foundation soil is not good and compaction layer or foundation that is not good, resulting in additional compaction by traffic load. Types and causes of distortion must be known to determine the appropriate type of repair.
3.	Disintegration	This damage is a defect on the surface of the pavement in the form of damage to roads perkeraan layer mechanically and chemically. Forms of damage can be Potholes, raveling, stripping. The causes can vary because the drainage system is not good, weather influences, material that does not comply with the specification.
4.	Polished aggregate	The existence of polished aggregate causing slippery roads and dangerous for vehicle and driver through the lane. The cause of this damage is not a wear-resistant aggregate material to the wheels of vehicles, aggregates that are round or cubical shaped not slick. How to fix that with the closure of defective parts with the appropriate layer.
5.	Bleeding or flushing	The road surface becomes slippery and dangerous for the vehicle across the road. Under conditions of high temperature asphalt, the asphalt becomes soft and causes traces kemdaraan passing wheels on the road surface. Bleeding caused by the use of high content of asphalt in the asphalt mix, asphalt excessive use on the job tack coat and prime coat. This type can be improved by sowing aggregate heat and compaction, or removal of the asphalt layer and providing a cover layer.
6.	Utility cut depression	In the former planting done compaction utilities that do not qualify so a decline throughout the section. This type can be fixed with the demolition of the section and replace it with an appropriate compaction and road construction superimposed with a suitable pavement.

Source: Manual (1983)

The type of damage such as cracks in Table 3 as follows:

**Table 3 Types of Cracks**

No.	Type of cracks	Descriptions
1.	Hair Cracking	The existence of a gap width of about 3 mm or smaller due to poor pavement materials, subgrade or the instability of the soil beneath the surface layer. Fine cracks can lead to water infiltration into the lining so that fine cracks develop into cracks crocodile skin. To fix the fine cracks can be used latasir or free-range layers and to repair the drainage system on the left and right of the road.
2.	Alligator cracks	This crack measuring about 3mm or greater that are interconnected to form a series of small squares like crocodile skin form. This is the cause of cracked pavement materials that are not good, the surface weathering, soil instability base or foundation layer sections condition that saturated water. In general, the location of occurrence of cracks crocodile was not extensive. If the location of the occurrence of cracks crocodile extends possibilities looping caused by traffic loads that exceed the maximum load that can be retained by the road surface layer. On the pavement there are cracks crocodile skin so that the water seeps into the base course and subgrade improved with dismantling and disposal of parts wet and resurfacing with appropriate material specifications. Improvement of drainage in the surrounding streets also have to be done because water can seep through cracks crocodile skin that causes the release of a grain aggregate and then cause holes in a certain period.
3.	Edge cracks	Damage in the form of cracks extends the road with branches or not located near the shoulder of the road leading to the shoulder of the road. The cause of this cracking is the support side is not good, the settlement on the land base or the surrounding area, drainage is not good, the destruction by the roots of plants growing in the surrounding streets or going on shrinking land, damage will get worse if the water is infiltrated entrance pavement through the cracks of the potential holes. How to repair this damage by filling cracks with a mixture of bitumen and sand, improvement of drainage in the vicinity, road widening and shoulder compaction. For the case of a decline on the edge of the pavement can be fixed elevation with hotmix.
4.	Edge joint cracks	Damage in the form of longitudinal cracks in the pavement and the shoulder joint caused by poor drainage below the shoulder of the road, the settlement on the road shoulder, the shoulder material shrinkage, the trajectory of the truck or heavy vehicle on the shoulder of the road. Repairs carried out such repairs for reflection cracks.
5.	Lane joint crack	Damage to the connection of two lanes of traffic in the form of longitudinal cracks caused by bonding the two-lane connection is not good. Cracks were not immediately rectified could widen as a result of grain material separated at the edges of the crack and allow the rain water into the pavement. How to fix that by incorporating a mixture of sand and liquid asphalt in the crevices.
6.	Widening Cracks	Damage in the form of longitudinal cracks at the connection between the old pavement to the new pavement for widening. The cause is the difference in the carrying capacity of the new and the old pavement, the bond between a poor connection. How to repair the damaged filling gaps with a mixture of liquid asphalt and sand. The omission of this damage causes water to seep into the pavement causing the grains apart and cracks grow.

7.	Reflection Cracks	Damage in the form of transverse cracking, longitudinal, diagonal or box form that occurs in pavement overlay (additional layer) which describes the pattern of cracks at the bottom due to long layers were fractured not corrected well before the overlay work. This damage can also occur due to vertical or horizontal movements beneath additional layers due to changes in the water content of expansive soil. How to repair a crack that is box-shaped with the demolition of damaged parts and resurfacing the section with appropriate materials. While crack repair method lengthwise, crosswise and diagonally with a gap filling cracks with a mixture of liquid asphalt and sand.
8.	Shrinkage Cracks	Damage in the form of continuous cracks forming huge boxes with sharp corners, it is a cause of damage to volume changes in the surface layer using asphalt with low penetration, volume changes in the base layer and subgrade. How to repair the filling cracks with a mixture of liquid asphalt and sand and resurfacing.
9.	Slippage Cracks	This form of damage such as cracks curved like a crescent moon, which is caused by poor bonding between the surface layer with the layer below it due to dust, oil, water, or objects other non-adhesive. Damage can also be caused due to: in between the two layers there is no bonding material such as tack coat; on the surface of the coating mixture contained too much sand; compacting the surface layer that is not good. How to repair the damage demolition and replacement parts with the corresponding layer.

Source: Manual (1983)

Distortion damage types can be distinguished in Table 4 below:

Table 4 Types of Distortion

No.	Types of Distortion	Descriptions
1.	Ruts	This damage occurs on the surface of the road is crossed wheels of the vehicle parallel to the road as caused by a less dense layer of pavement so that the addition of compaction by repetition of traffic loads on the track wheels of the vehicle. This damage becomes a menggenangnya rainwater that falls on the surface of the road. The fix for this damage by providing an additional layer on top of the surface layer.
2.	Corrugation	The transverse grooves occur causing inconvenience for road users. This damage occurs due to low stability due to the mixture of asphalt content is too high, excessive fine aggregate, the aggregate is round too much. This damage can also occur in the use of liquid asphalt pavement because the road was opened for public traffic when the pavement has not been steady. Repair this damage by the way: back scratching, mixing with the base course, compaction back and giving a new surface layer.
3.	Shoving	Damage in the form of local plastic deformation, with or without retak. Penyebab damage equal to the damage corrugation. Occur in places with a steep slope, sharp turns and stop the vehicle. Repair the damage by way of dismantling the damaged part and the resurfacing of the section.
4.	Grade Depression	Local damage that occurs with or without cracking. This damage is detected the presence of stagnant water that could seep into the pavement and cause holes. The cause of damage, namely: a decrease in part because the pavement subgrade settlement experiencing example in the case basically peat soil which may have tertiary considerable consolidation, execution of road works less well, the vehicle load exceeds the load capable borne by pavement. How to repair with: a) charging the low parts with the appropriate materials to vanish smaller than 5 cm; b) dismantling section collapsed and resurfacing with layers corresponding to vanish greater than 5 cm.
5.	Upheaval	Local damage occurred in the presence of cracks or no cracks, due to the development of the subgrade soil ekspansif basis. How to repair the damage by dismantling the damaged part and coating the parts after dismantling.

Source : Manual (1983)

Type of disintegration damage can be distinguished in Table 5 below:

Table 5 Types of Disintegration

No.	Types of Disintegration	Descriptions
1.	Potholes	The shape of the bowl with a small to large sizes. Potholes existence can collect rainwater and cause the collected water infiltration into the pavement so that damage to roads increases parah. Penyebab occurrence of holes, namely: the mixture of surface layer of material that is not good (low bitumen content of asphalt so that the film is thin and easily separated; the bond between asphalt and aggregate is not good because the aggregate gross; non-fulfillment of the mixture temperature as standard .; thin surface layer of asphalt and aggregate bond resulted because of the influence of the weather becomes easily detached; good drainage system does not cause the amount of stagnant water which is then infiltrated into the pavement; Handling is slow to decay cracks resulting in stagnant water to seep through the cracks make small holes which longer be a big hole. Repairing Potholes by way of dismantling and resurfacing. Repair permanently with deep patch can be done with procedures: cleaning holes of water and material -material loose, dismantling parts of the surface layer and deep foundation so as to achieve a solid layer (cutting with a rectangular shape), giving tack coat layer to layer binder, charging mix asphalt sekssma to avoid segregation, compacting the mixture and form surface layer appropriate conditions.
2.	Ravelling	This damage can be widespread by the impact and cause the same type of damage to the hole. Improvement by providing an additional layer on top of the damaged layer after cleaned and dried first layer are damaged.
3.	Stripping	The cause of this damage is less bonding between the surface layer and the layer below it, or because the surface layer is too thin. Repair this damage by means raking the damaged part, then conducted leveling, compacting and coating.

Source : Manual (1983)

The road damage can be divided into two categories as structural damage and functional damage. The B.C. Ministry of Transportation (2007) has identified there are 12 (twelve) types of damages in the road failure. Then the 12 (twelve) damages is being grouped into 3 (three) types of damages, such as: a) cracking, including: longitudinal wheel path cracking, longitudinal joint cracking, pavement edge cracking, transverse cracking, meandering longitudinal cracking, and alligator cracking; b) type of surface deformation such as: rutting, shoving and distortion; and c) type of surface defects such as: bleeding, potholes and ravelling. Besides that Ditjen Bina Marga (2006a) has grouped the road damage into 3 (three) types, such as: potholes type, rutting type and deformation type.

Others researcher stated several kind of classification of road damage. Firstly, Gedafa (2006) classified 3 (tiga) type of structural damages such as: potholing, rutting and texture depth. Secondly, Drakos (2007) concluded that 3 (type) of road damages that often occurred such as: a) type of rutting, including consolidation rutting and instability rutting; the damaged is began with the form of cracking; b) type of potholes, this one is began in the form of ravelling; and c) type of depression, it is began with the deformation. Thirdly, Watanatada et al. (1987) has grouped the kind of road damages into 4 (four) types, such as: a) rutting and cracking; b) potholes; c) distortion and deformation; and d) ravelling and corrugation. Fourthly, Sjahdanulirwan and Nono (2005b) has stated the 3 (three) group of road damages such as: a) group of cracks, it is dominated of alligator crack; b) group of disintegration, it is dominated of the holes in the surface; and c) group of deformation. Fifthly, Bennett (2004) and Bennett (2007a,b) concluded that there are 8 (eight) kind of the road damages that often occurred, such as: a) alligator cracking; b) longitudinal and transverse cracking; c) rut depth; d) shoving; e) potholes; f) scabbing; g) flushing; and h) edge break.

Extreme weather is the important factor that cause road damage such as flooding after a heavy rain. Also unstable soil conditions can be found at the road on the peatland. It was known that the peat have the low shear strength, high compressibility and high water content.

According to Onuoha and Onwuka (2014), the soil geotechnical characteristic is a causative factor of the road failure. The other researcher, Mahmoud et al (2012) concluded that road pavement failure along Gombi-Biu, Highway, Nigeria is caused by the poor geotechnical properties of soil.

Suswandi et al (2008) reported the result of study at South Ring Road, Yogyakarta, Indonesia that the types of road distress included alligator cracking, depression, block cracking, longitudinal and tranverse cracking, polished aggregate, patching, slippage cracking, shoving and weathering or gravelling. The damages at the road is found only on some parts of segments. The suggestion that it was better make some adjustments of treatment for the damages of road.

## II. Methods

### Study Site

This study was conducted in Bukit Keminting street at Palangka Raya City, Central Kalimantan, Indonesia. The length of road is 3,500 m and width is 8 m. These locations can be represent the damaged of road on peatland significantly. This research used quantitative methods for data collection in the field and secondary data of soil from several researchers.



Figure 1 Road Network Map of Palangka Raya City (Department of Civil Works, 2010)

The observation of road damages is done at 1 September until 8 September 2013.

### III. Climate

The climate data from Meteorological and Geophysics Station City of Palangka Raya that City of Palangka Raya area has an annual rainfall over the last 10 years (1997-2006) ranged from 1.840 to 3.117 mm by 2.490 mm average. Air humidity is 75-89%, with an annual average humidity of 83.08%. The average temperature is 26.8800C with minimum temperature and maximum temperature 32.5200C 22.9300C.

Table 6. Number of Rainy Day, Average Precipitation, Wind Speed, Temperature, and Humidity city of Palangka Raya in 2011

Month	Rainy Day	Average Precipitation (mm)	Wind Speed	Average of temperature (°C)	Humidity (%)
1	2	3	4	5	6
January	22	317.3	2	26.7	85
February	24	280.3	2	27	86
March	26	511.1	3	27	85
April	23	356.2	3	27	86
May	16	376.6	2	28	84
June	9	36.1	2	27.5	83
July	10	122.9	2	26.9	82
August	7	26.6	3	27.7	79
September	10	176.5	3	26.7	82
October	17	414.9	2	28.3	81
November	24	427.2	2	27.4	85
December	30	388.9	2	26.5	89

1 knot= 1.8 km/jam

Source: Meteorological and Geophysics Station City of Palangka Raya (2012)

### Data of Soil

The data of soil was taken from the location near Palangka Raya City, the peat commonly has the same characteristic with several soil properties in Palangka Raya.

Table 7. The Result of Physical Soil Properties of Bukit Rawi Peat

No	Laboratory Testing	Unit	BH1	BH2	BH3	Average
1	Natural water content	%	372,89	377,28	365,91	372,03
2	Unit Weight ( $\gamma$ )	g/cm <sup>3</sup>	0,94	0,95	0,97	0,95
3	Specific Gravity (Gs)		1,57	1,63	1,43	1,54
4	Organic Matter	%	55,93	53,33	57,61	55,62
5	Ash Content	%	44,07	46,67	42,39	44,38
6	Fiber Content	%	36,26	35,48	46,44	39,39
7	Partikel Size					
	- Rough fiber	%	40,16	54,21	42,88	45,75
	- Medium fiber	%	35,02	30,27	31,15	32,15
	- Smooth fiber	%	24,82	15,55	25,198	21,86
8	Acidity (pH)		3,8	3,4	4,2	3,8

Sumber : Sarie and Sastro (2015)

According to ASTM D 4427- 92 (1996) the peat soil of Bukit Rawi based on the ash content is classified as high ash peat (44.38%), This peat is hemic (39.39%), moderately Absorbency (the water content is 372.03%), highly acidity (pH is 3.8) and fibrous peat (the fibrous content is more than 20%).

The observation of the traffic showed that there were the case of overloading of loads of the vehicles. This situation make a contribution to road damage.

#### IV. Results and discussion

Data of road pavement damaged that occurred on Jalan Bukit Keminting based on observations in the field of visual and measurement of damages as well as the photo-documentation in the field, obtained the results as shown in Table 8.

Table 8. Types of Damage

No.	Description	Area (m <sup>2</sup> )	% of damages
1.	Potholes	48	1.501
2.	Hair cracks	800	25.16
3.	Alligator cracks	100	3.127
4.	Edge cracks	600	18.762
5.	Depressions	1500	46.904
6.	Ravelling	150	4.690
Total of damages		3198	100.000

Source: observation (2013)

The type of road damages in Palangka Raya are depressions, hair cracks, edge cracks, raveling, alligator cracks, potholes. With the variety of the damage caused inconvenience for road users. Road repairs have been done but the damage is almost as still occur because of the rain that falls on the surface of road pavement does not flow into the drainage channel in the vicinity due to the elevation of the road and the land next to the road that do not allow rainwater to flow into drainage channels lead to water flooded the edge of the road and entrance through the cracks are beginning to occur and the more severe because it is not addressed immediately.

There are several factors that cause the damages. Among the other factor that factors causing these damages are a factor of environmental conditions (regional factor) around such local factors concerning the state of the pitch and climatic influences the state of load carrying capacity of the land and also the weather in that location. The documentation was taken from the street. There were several type of damage has been documented to describe the kind of road damage in Palangka Raya.

#### V. Conclusion

The type of road damages in Palangka Raya can be grouped by 3 (three) types of damages such as: a) type of cracks; b) type of disintegration, dominated by potholes, this one is began in the form of ravelling; and c) type of depression, it is began with the deformation.

Several maintenance project has been done to improve the road condition. In the future it is important to design the road which consider the factors that effect the road damages and to consider the overloading of vehicles.

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