JOURNAL OF SCIENCE AND APPLIED ENGINEERING (JSAE), May 2018, Vol 1 (1), 1-9
E-ISSN: 2621-3753
P-ISSN:2621-3745

ANALYSIS OF ROAD SURFACE DEFECTS USING ROAD CONDITION INDEX METHOD ON THE CARUBAN-NGAWI ROAD SEGMENT

A. Suraji[1], A. T. Sudjianto[1], Riman[1]
[1]Department of Civil Engineering, University of Widyagama, Malang, Indonesia

ABSTRACT

Road maintenance action program must begin with identification of road surface defects before compiling a work program. One method of identification of road defects is the Road Condition Index (RCI) method. This method is simpler than the other methods because the survey method is by visualizing. This study aims to identify road defects with the RCI method carried out by several surveyors and how defects occur on the Caruban-Ngawi road section.
The method used in this study is by direct survey of primary data on road surface defects conditions. There were 3 surveyors who conducted a survey with normal and opposite directions along the road. Data slices are made at lengths of every 100 m to identify road defects. The data is processed by doing an average on each data which is then made a strip map of road defects image. Data processing was done by determining the percentage of defects categories ranging from good, moderate, light defects, and heavy defects.
The results of the study showed that the survey conducted by several surveyors was good and the general results were not significantly different. This means that the surveyors have almost the same perception in terms of assessing the condition of road defectss with the RCI method. The condition of road pavement on the Caruban-Ngawi road in general can be said that the road is still in good condition where heavy defects road damage in the normal and opposite directions is only 1.13% and 0.28% respectively.

Keywords road, surface defects, RCI method, strip map
Paper type Research paper

INTRODUCTION

The quality of road services is strongly influenced by the presence of road pavement conditions. If the condition of the road pavement is good then the speed of the vehicle will be more stable, as well as the comfort of the road users better and traffic safety will be better. For this reason, realizing good road pavement conditions based on the Road Design Guidelines is by increasing road services, which in this case the quality of road surface. Pavement design in accordance with quality standards is very important to realize so that road services can be better [1], [2].
To determine the condition of road pavement, the identification of road defects is very important because it will be used for road handling plans [3], [4]. Of course the handling of the road is in accordance with the conditions of road defects, if the defects is a little, the handling is simpler, but if the defects is heavy, the handling requires a greater cost. The type of defects and the handling plan are regulated in accordance with Bina Marga standards as contained in Table 1 [5]. The identification method for road defects can also refer to the method that has been developed by Suraji using the RCI method [6].

TABLE 1. ACTION PROGRAM FOR ROAD MAINTENANCE

Road condition	Percentage of damage (%)	Road maintenance program
Good (G)	< 6	Routine Maintenance
Moderate (M)	6 - 11	Minor Rehabilitation
Light damage (LD)	11 - 15	Major Rehabilitation
Heavy damage (HD)	> 15	Reconstruction

Measurement of road surface quality can be done by various methods, and in general can be divided into two types, namely pavement surface measurements and measurement of the strength of the pavement structure. The simple method of road surface measurement is to use the RCI method (Road Condition Index) where this method emphasizes visual observation by surveyors in the field [7]. The spread of road defects can be caused by various kinds of them due to more burdens such as research that has been carried out by Suraji, poor soil conditions, non-functioning drainage systems and others such as the research conducted by Sudjianto [8]–[13]. The objectives of this research is to identify road surface conditions using the RCI method and conduct road defects analysis.

METHOD

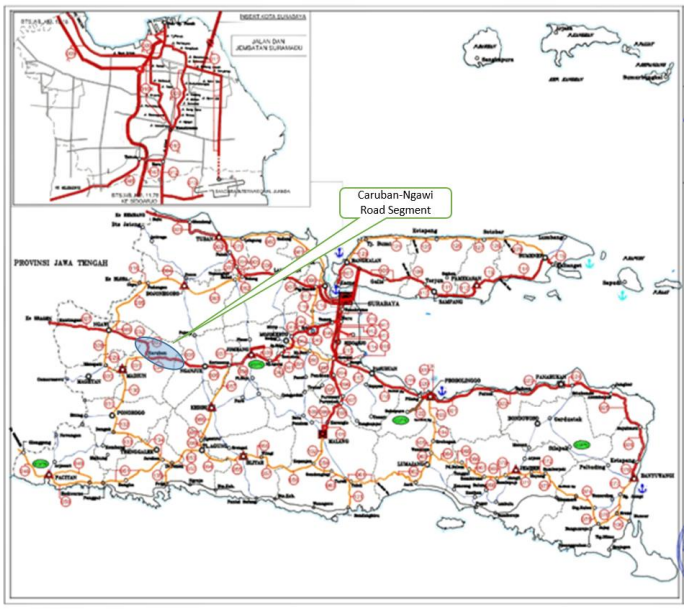
Conceptual Framework

The defects of the road surface in a segment can be caused by a variety of reasons with different types of curling [14], [15]. The crust can be in the form of surface cracks, grooves on the road lane, holes on the road surface, wavy both in the direction and across the road surface. Each type of defects is usually caused by a number of factors which pattern can be followed by a causal factor [16], [17].

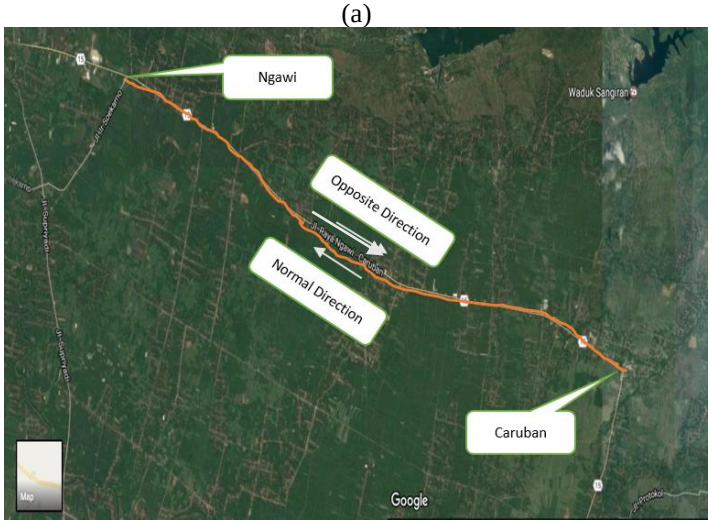
Road damage was identified visually by surveyors using the basic criteria for defecting the road with a score system. Furthermore, from the results of the RCI survey, it is recapitulated to a segment which is the result of identification of road defects. While the types of defects that have been identified are used to make strip map of road defects.

Location of Research

The location of this research is on the Caruban-Ngawi road section. This road is a national road segment with a classification of primary arteries. This road is included in the area of Madiun Regency and Ngawi Regency, East Java Province. Map of the Caruban-Ngawi area and road section as shown in Fig 1.



(a)



(b)

Fig. 1. (a) Location of research on the Caruban-Ngawi in East Java Province map, (b) The Caruban-Ngawi road segment

Procedure of Identification

RCI measurements are based on predetermined scales, ranging from 1 to 10, where low to high values indicate the level of the worst conditions to good conditions. A value of less than 2 indicates the condition of the road in conditions of heavy defects, where the vehicle can pass through only off road vehicles. While the value scale 8 to 10 shows the condition of flat and regular pavement. More detailed RCI rating scales can be seen in Table 2.

Field surveys to obtain RCI data are based on field survey forms. RCI identification is made segmentation every 100 m, where each surveyor fills his own RCI assessment independently. This independent personal assessment is important to obtain the RCI assessment objectivity.

Furthermore, the results of RCI assessments that have been processed are strip folders along the road. The strip map created was intended to obtain a continuous picture of the results of RCI's assessment. The RCI rating scale was converted into a scale of rating of road conditions in 4 levels, namely good, moderate, light defects, and heavy defects. In making strip maps, the level of assessment is represented in color, namely the green color for good conditions, yellow for moderate, brown conditions for light defects conditions, and red for heavy defects conditions. This level of road surface defects is in accordance with the guidelines issued by Bina Marga [4].

For more detailed identification of road defects and their causes, it can be done by identifying each type of defects. Types of defects such as wheel grooves, holes, bumps are observed and actual conditions that occur in the field. By using a road defects guideline reference, each type of defects can be suspected of being determined [18]–[20].

TABLE 2. RCI SCALE FOR ROAD DAMAGE IDENTIFICATION

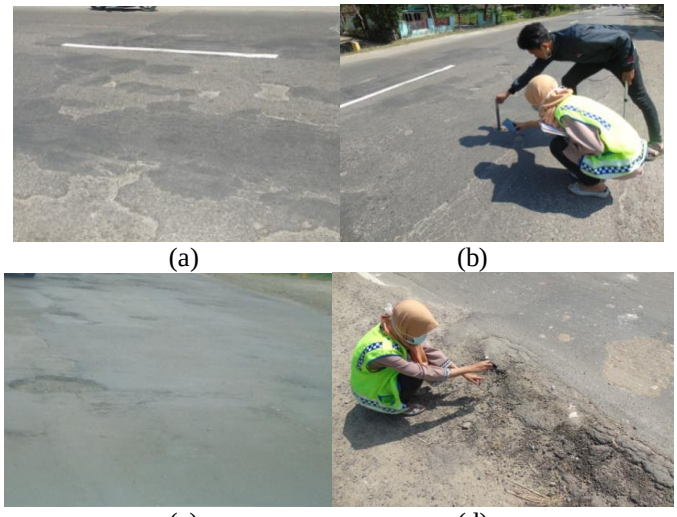
RCI Scale	Road surface condition by visual survey	Road pavement condition	Road condition for Strip map Scale
8-10	Flat and smooth	New pavement	
7-8	Very good and flat	2 year old of pavement	Good
6-7	Good	New overlay	
5-6	Little pothole, not smooth	Routine maintenance	
4-5	Poor, pothole, not smooth	2 year after maintenance	Moderate
3-4	Road defects, bumpy road, pothole	No maintenance	Light defects
2-3	Heavy defects, pothole	No maintenance for 5 years	Heavy defects
≤ 2	No access for vehicle except for off road vehicle	Non pavement road, poor drainage.	

DISCUSSION

Data Collecting

RCI data collection has been carried out along the 34.5 km road section. Types of defects and levels of defects were identified based on the RCI survey guidelines. Field survey photos as shown in Fig 2. In the Fig 2, various types of road defects have been identified such as cracking, rutting, pothole, and deformation.

RCI data from the field survey results have been processed and presented in Table 3. In this table a survey of 3 surveyors with different directions was obtained, namely the normal direction and the opposite direction. Data slices are made every distance of 100 m with the station identity (STA) where each distance is used as the basis for making strip maps. The results of a survey conducted by 3 surveyors occurred with variations in RCI results but these differences were not significant. This can be seen from the field RCI values which are generally only one level of assessment. This means that there are no differences that are far from the results of the three surveyors. This means that the surveyors already have a relatively similar perception to identify road defects with the RCI method. The results of this study are in line with the research conducted by Sarie and Utomo where the research was conducted in Palangkaraya [21], [22].



(a) (b)

(c) (d)

Fig. 2. Road condition identification: (a) Cracking, (b) Rutting (c), Pothole (d) Deformation.

TABLE 3. DATA COLLECTING FOR RCI SURVEY (SAMPLING DATA)

Road Segment		: Caruban - Ngawi					
Length of road segment		: 35.40 km					
Date of Survey:		: 5 Mei 2018					
Surveyor		: (1) Sukesi; (2) Dwi (3) Anjar					
No	Station (STA)	Direction					
		Normal			Opposite		
		Surveyor 1	Surveyor 2	Surveyor 3	Surveyor 1	Surveyor 2	Surveyor 3
1	0+000 - 0+100	`	8	7	7	6	6
2	0+100 - 0+200	7	7	7	7	6	6
3	0+200 - 0+300	7	7	7	6	6	6
4	0+300 - 0+400	7	8	7	6	6	6
5	0+400 - 0+500	7	8	7	6	6	6
6	0+500 - 0+600	7	7	7	5	5	6
7	0+600 - 0+700	6	5	7	2	3	3
8	0+700 - 0+800	6	6	7	4	3	4
9	0+800 - 0+900	6	6	7	6	6	7
10	0+900 - 1+000	5	5	5	7	6	7
11	1+000 - 1+100	5	5	5	7	6	6
12	1+100 - 1+200	5	5	5	6	6	7
13	1+200 - 1+300	5	6	5	7	6	6
14	1+300 - 1+400	5	5	5	6	6	6
15	1+300 - 1+400	5	5	4	6	6	6
16	1+400 - 1+500	5	6	5	6	6	6
17	1+500 - 1+600	6	7	6	6	6	6
18	1+600 - 1+700	6	8	6	6	6	6
19	1+700 - 1+800	6	8	7	6	6	6
20	1+900 - 2+000	6	7	6	6	6	6

Analysis and Discussion

After getting the field data then the data is processed by determining the average RCI value from the 3 surveyors in each direction, namely the normal direction and the opposite direction. The results of the RCI data processing are shown in Table 4. The table only shows data sampling for 2 km. The strip map display defects the path according to the data slices and the results are shown in Fig 3.

Furthermore, the full data is displayed in the form of a nomogram as shown in Fig 4. In Fig 4 it includes all 35.4 km of data with 354 slices of data. In this nomogram display reading RCI value data cannot be seen and displayed in detail. However, the reading of the monogram is more seen in a broadly fluctuating context that occurs along the road. Research conducted by several previous researchers has also presented defects data with various methods both in the form of tables and strip maps [14], [19], [22].

Based on the results of data processing, it is obtained that heavy defects in the normal direction is 1.13%, while the opposite direction is 0.28%. The results of data processing are as shown in Table 5. Statistically the normal direction has obtained a minimum value of 3.00 maximum 8.00 with a standard deviation of 0.74. Whereas for the normal direction, the minimum value of 2.67 has been obtained, maximum 7.33 with a standard deviation of 0.54. The proportion of road defects can be used as a basis for handling roads both in terms of maintenance conditions, minor rehabilitation, major rehabilitation, and reconstruction [19], [20].

In general it can be said that the value of defects for the type of heavy defects is still less than 5% of the total defects, it can be said that the road is still in good condition. However, some locations have light defects and moderate where the defects can be overcome by the type of major or minor rehabilitation. The results of research conducted by Wada and Wang about road defects also revealed the existence of various types of defects caused by various causes both by traffic and the failure of the pavement structure [23], [24].

TABLE 4. RCI VALUE ON NORMAL AND OPPOSITE DIRECTION (SAMPLING DATA)

No	Data slices (STA)	Average of RCI	
		Normal direction	Opposite direction
1	0+000 - 0+100	7.3	6.3
2	0+100 - 0+200	7.0	6.3
3	0+200 - 0+300	7.0	6.0
4	0+300 - 0+400	7.3	6.0
5	0+400 - 0+500	7.3	6.0
6	0+500 - 0+600	7.0	5.3
7	0+600 - 0+700	6.0	2.7
8	0+700 - 0+800	6.3	3.7
9	0+800 - 0+900	6.3	6.3
10	0+900 - 1+000	5.0	6.7
11	1+000 - 1+100	5.0	6.3
12	1+100 - 1+200	5.0	6.3
13	1+200 - 1+300	5.3	6.3
14	1+300 - 1+400	5.0	6.0
15	1+300 - 1+400	4.7	6.0
16	1+400 - 1+500	5.3	6.0
17	1+500 - 1+600	6.3	6.0
18	1+600 - 1+700	6.7	6.0
19	1+700 - 1+800	7.0	6.0
20	1+900 - 2+000	6.3	6.0

Data slices (STA)	KM	0										1									
	meter	000	100	200	300	400	500	600	700	800	900	000	100	200	300	400	500	600	700	800	900
RCI Value	Normal Direction	7.3	7.0	7.0	7.3	7.3	7.0	6.0	6.3	6.3	5.0	5.0	5.0	5.3	5.0	4.7	5.3	6.3	6.7	7.0	6.3
	Opposite direction	6.3	6.3	6.0	6.0	6.0	5.3	2.7	3.7	6.3	6.7	6.3	6.3	6.3	6.0	6.0	6.0	6.0	6.0	6.0	6.0
		Legend of RCI Scale:																			
		6 - 10	=	Good			=	Green													
		4 -6	=	Moderate			=	Yellow													
		3 -4	=	Light defect			=	Brown													
		0 - 3	=	Heavy ddefect			=	Red													

Fig. 3. Strip map of the road condition (sampling data)

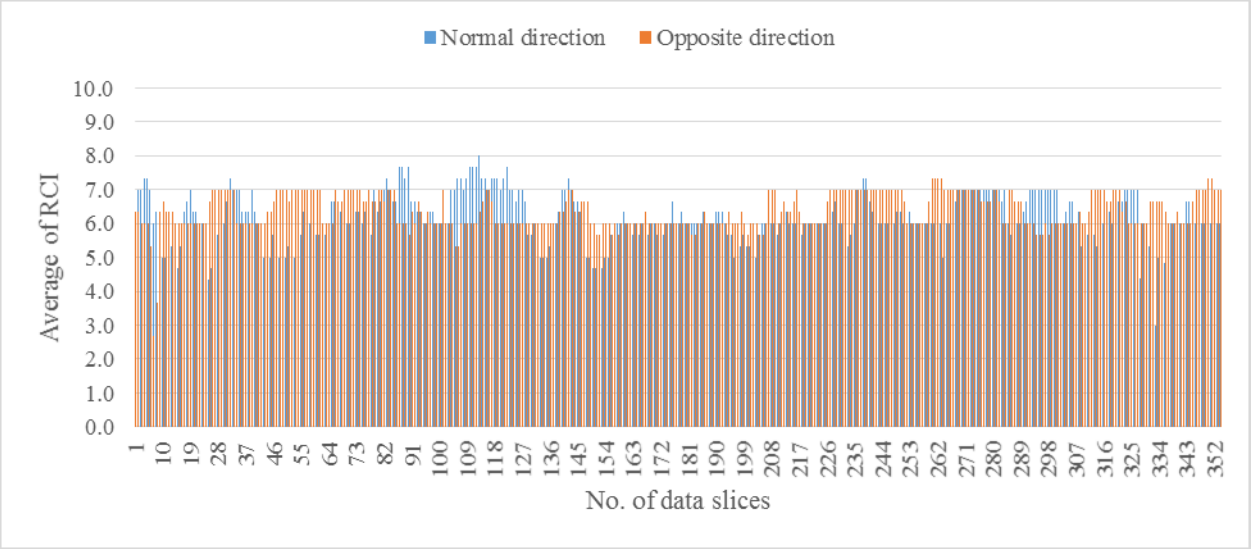


Fig. 4. Nomogram of RCI value on the Caruban-Ngawi road segment (all data)

TABLE 5. RESUME RCI DATA BASED ON ROAD CONDITION

Road condition	Normal direction		Opposite direction	
	No. of data slices	Percentage (%)	No. of data slices	Percentage (%)
Good (G)	253	71.47	334	94.35
Moderate (M)	81	22.88	18	5.08
Light defect (LD)	16	4.52	1	0.28
Heavy defect (HD)	4	1.13	1	0.28
Total	354	100.00	354	100.00
Statistic Analysis:				
Minimum value	3.00		2.67	
Maximum value	8.00		7.33	
Deviation standard	0.74		0.54	

CONCLUSION

Based on the analysis and discussion of road defects, it can be concluded as follows:

1) The results of the field RCI survey conducted by the three surveyors in general there were no significant differences so the three surveyors had the same perception of road defects. This RCI method can generally be used to identify road defects in an easy and inexpensive way.
2) The condition of the Caruban-Ngawi road in general can be said to be still in good condition where the heavy defects that occurs is only a small percentage, namely in the normal direction of 1.13%, while the opposite direction is 0.28%. The handling of the Caruban-Ngawi road is sufficient by maintaining routine conditions.

ACKNOWLEDGMENT

The research team expressed many thanks to the Minister of Research and Higher Education for providing research funding for the Higher Education Applied Research Scheme in the 3rd year of the 5-year plan.

REFERENCES

[1] Direktorat Jenderal Bina Marga, *Manual Perkerasan Jalan No. 04/SE/Db/2017*. 2017.
[2] Peraturan Menteri Pekerjaan Umum No. 19/PRT/M/2011, *tentang Persyaratan Teknis Jalan dan Kriteria Perencanaan Teknis Jalan*. 2011.
[3] Direktorat Jenderal Bina Marga, *Panduan Survei Kondisi Jalan No. SMD-03/RCS*. 2005.
[4] Peraturan Menteri Pekerjaan Umum No.13/PRT/M/2011, *tentang Tata Cara Pemeliharaan dan Penilikan Jalan*. 2011.
[5] Direktorat Jenderal Bina Marga, *Panduan Survei Kekasaran Permukaan Jalan Dengan Alat Ukur NAASRA*. 2005.

[6] A. Suraji, "Metode Identifikasi Kerusakan Jalan dan Penanganannya," Karya Intelektual-Hak Cipta No. 000121941, 2018.
[7] Direktorat Jenderal Bina Marga, *Panduan Survai Kekasaran Permukaan Jalan Secara Visual No. SMD-04/RS(2)*. 2005.
[8] S. Hussain, "Effect of Compaction Energy on Engineering Properties of Expansive Soil," *Civil Engineering Journal*, vol. 3, no. 8, pp. 610–616, 2017.
[9] A. T. Sudjianto, K. B. Suryolelono, A. Rifa'i, and I. B. Mochtar, "The Effect of Water Content Change and Variation Suction in Behavior Swelling of Expansive Soil," *International Journal of Civil and Enviromental Engineering*, vol. 11, no. 3, pp. 11–17, 2011.
[10] A. T. Sudjianto, K. Suryolelono, A. Rifa'i, and I. Mochtar, "Behaviour Expansive Clay of Ngawi Region (East Java)," *Journal Civil Enggineering Dimension (CED), UK Petra Surabaya*, vol. 11, no. 2, pp. 100–105, 2009.
[11] A. Suraji, A. T. Sudjianto, and Riman, "Analisis Perbandingan Nilai CESA Kendaraan Berat antara Muatan Kosong dengan Muatan Standar," in *Prosiding Seminar Nasional Ciastech 2018*, Universitas Widyagama Malang, 2018, pp. 530–537.
[12] A. Suraji, A. T. Sudjianto, A. Candra, and Riman, "Pengaruh Beban Lebih (Overload) Kendaraan Berat terhadap Faktor Ekivalen Beban (VDF) pada Ruas Jalan Caruban-Ngawi," in *Mengatasi Krisis Tenaga Ahli Konstruksi Bersertifikat Di Indonesia*, Universitas Narotama Surabaya, 2016.
[13] I. Udiana, R. Andre, A. R. Saudale, and J. J. S. Pah, "Analisa Faktor Penyebab Kerusakan Jalan (Studi Ruas Jalan W.J. Lalamentik dan Ruas Jalan GOR Flobamora)," *Jurnal Teknik Sipil*, vol. 3, no. 1, pp. 13–18.
[14] R. T. Bethary, M. F. Perdana, and N. G. Lestari, "Analisis Kerusakan dan Perencanaan Tebal Perkerasan Jalan Kaku dengan Metode Bina Marga 2003," *Jurnal Fondasi*, vol. 2, no. 4, pp. 39–47, 2015.
[15] E. M. Bolla, "Perbandingan Metode Bina Marga dan Metode Pavement Condition Index (PCI) Dalam Penilaian Kondisi Pekerjaan Jalan Studi kasus jalan Kaliurang, Kota Malang," *Jurnal Teknik Sipil*, vol. 12, no. 4, pp. 78–86, 2011.
[16] A. Suraji, A. T. Sudjianto, A. Candra, and Riman, "Karakteristik Arus Lalu Lintas pada Ruas Jalan Caruban-Ngawi dan Proporsi Kendaraan Berat Selama 24 Jam Pengamatan," in *Inovasi Material Untuk Pembangunan Infrastruktur Di Indonesia*, Fakultas Vokasi ITS Surabaya, 2017, pp. 1–8.
[17] E. Yalçın, M. E. Çeloğlu, M. Yılmaz, and B. V. Kök, "Determination of Resistance to Creep Permanent Deformation of Hot Mix Asphalts Prepared with Various Additives," *Civil Engineering Journal*, vol. 4, no. 7, pp. 1553–1564, 2018.
[18] Ichasan, "Studi Evaluasi Tingkat Kerusakan Permukaan Jalan Untuk Menentukan Jenis Penanganan dengan Sistem Penilaian Menurut Bina Marga (Studi Kasus : Ruas Jalan Binereun-Takengon)," *Jurnal Teknik Sipil*, vol. 3, no. 2, pp. 62–72.
[19] Z. B. Rashid and R. Gupta, "Study of Defects in Flexible Pavement and its Maintenance," *International Journal of Recent Engineering Research and Development*, vol. 2, no. 6, pp. 74–77, 2017.
[20] S. Sameer, K. Bhutada, S. Poharkar, D. Chavade, and Kedarnath, "Road Defectss and Highway Maintenance," *Journal of Mechanical and Civil Engineering*, vol. 15, no. 2, pp. 43–47, 2018.
[21] F. Sarie, B. Bisri, A. Wicaksono, and R. Effendi, "Types of Road Pavement Damage for Road on Peatland, A Study Case in Palangkaraya, Central Kalimantan, Indonesia," *Journal of Environmental Science, Toxicology and Food Technology*, vol. 9, no. 12, pp. 53–59, 2015.
[22] P. Utomo, T. Tristono, A. Budiman, and R. K. Rohman, "Road Damage Classification using Back Propagation Algorithm," *International Journal of Advanced Research in Computer Science*, vol. 8, no. 3, pp. 510–514, 2017.
[23] S. A. Wada, "Bituminous Pavement Failures," *Journal of Engineering Research and Applications*, vol. 6, no. 2, pp. 94–100, 2016.
[24] J. Wang *et al.*, "Knowledge-Based Detection and Assessment of Damaged Roads Using Post-Disaster High-Resolution Remote Sensing Image," *Remote Sensing*, vol. 7, pp. 4948–4967, 2015.