INTERNATIONAL JOURNAL OF INTEGRATED ENGINEERING

The International Journal of Integrated Engineering (IJIE) is a single blind peer reviewed journal which publishes 3 times a year since 2009 (April, August and December). The journal is dedicated to various issues focusing on 3 different fields which are:-

Civil and Environmental Engineering. Original contributions for civil and environmental engineering related practices will be publishing under this category and as the nucleus of the journal contents. The journal publishes a wide range of research and application papers which describe laboratory and numerical investigations or report on full scale projects.

Electrical and Electronic Engineering. It stands as a international medium for the publication of original papers concerned with the electrical and electronic engineering. The journal aims to present to the international community important results of work in this field, whether in the form of research, development, application or design.

Mechanical, Materials and Manufacturing Engineering. It is a platform for the publication and dissemination of original work which contributes to the understanding of the main disciplines underpinning the mechanical, materials and manufacturing engineering. Original contributions giving insight into engineering practices related to mechanical, materials and manufacturing engineering form the core of the journal contents.

CURRENT ISSUE

Vol 11 No 9 (2019): Special Issue: Civil Engineering

PUBLISHED: 2019-12-30

ARTICLES

MAKE A SUBMISSION

Focus and Scope

Editorial Board

Guideline for Authors

Indexing and Abstracting

Publishing Ethics

Copyright and License

Open Access Policy

Charge

Indexed by:

Scopus

Google Scholar

Malaysian Citation Centre

ISSN : 2229-838X e-ISSN : 2600-7916

UTHM
Universiti Tun Hussein Onn Malaysia

PUBLISHED: 2019-12-30

ARTICLES

MAKE A SUBMISSION

Focus and Scope

Editorial Board

Guideline for Authors

Indexing and Abstracting

Publishing Ethics

Copyright and License

Open Access Policy

Charge

Indexed by:

Scopus

Google Scholar

Malaysian Citation Centre

ISSN : 2229-838X e-ISSN : 2600-7916

Universiti Tun Hussein Onn Malaysia

© Universiti Tun Hussein Onn Malaysia Publisher's Office

IJIE

Journal homepage: http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN : 2229-838X e-ISSN : 2600-7916

The International Journal of Integrated Engineering

Rehabilitation Planning for Flexible Pavement using Rebound Deflection Method and PCI Method on Triwidadi Road of Yogyakarta

Emil Adly[1,*], Wahyu Widodo[1], Anita Rahmawati[1], J. N. N. R. Sri Atmaja Putra[1]

[1]Department of Civil Engineering, Faculty of Engineering,
Universitas Muhammadiyah Yogyakarta, Daerah Istimewa Yogyakarta 55183, INDONESIA

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2019.11.09.022
Received 21 February 2019; Accepted 16 October 2019; Available online 31 December 2019

Abstract: Triwidadi Road, located in the Pajangan area, Bantul, Special Region of Yogyakarta Province in Indonesia is characterised as local road in accordance to its function, and is classified as poor category based upon the PCI results. Damages scattered on the road section often cause an uncomfortable feeling of the road users, and may also potentially cause traffic accidents. An overlay addition is considered to be a solutive alternative to improve the road pavement structure in order to ensure its appropriateness and service quality to the road users. This study uses the rebound deflection method with the Benkelman Beam which is based on the Pd T-05-2005-B regulation. The studied road was 4 km long, stationing at 14+000 - 18+000 with 50 meters range between one tested point to another, and was made as many as 20 segments. The results show that there is no significant correlation between functional layer damages with the structural road, which is shown from the comparison between data analysis with PCI result which stating the corrected overlay, hence recommendation solutions that can be offered to be performed are as follows: overlay addition for all segments are 4 cm, with Laston asphalt type with Resilient Modulus = 2000 MPa and Marshall Stability = 800 kg for a 10-year design life with CESA = 1,480,000 ESA.

Keywords: Benkelman Beam, Overlay, Pavement Condition Index, Rebound Deflection Method

1. Introduction

Being a local road receiving only little attention from the local government, the Triwidadi Road located in the Pajangan area, Bantul, Special Region of Yogyakarta is severely damaged and destroyed. The damaged road leads to discomfort and dissatisfaction among road users in addition to the threat of potential accidents. Road damages certainly lead to road rage and pose threat to the safety of road users. As a solution to the aforementioned problems, it is necessary for us to conduct an investigation of road deterioration and damages. An overlay addition is considered to be a good alternative to improve the road pavement structure in order to ensure its appropriateness and quality. Thus, this study aims to conduct deflection testing of the Triwidadi Road pavement for an overlay design on the subsequent road's pavement project. In addition, this study is also intended to investigate the correlation between the road functional damages and deflection in the field.

Flexible road pavement is a pavement which uses asphalt as a bonding material and typically consists of 4 layers namely surface course, upper base course, bottom base course, and subgrade course [10]. The functions of each layer are described as follows: (i) Surface course, has a function as a wheeled vehicles load-bearing layer, preventing surface water to enter the underlying structure layers, and serves as the wearing course, (ii) Base course, has a function as a

*Corresponding author: adly_zola@yahoo.com

laying base for the surface course and it provides additional load distribution to descend the traffic load into the bottom base course, (iii) Subbase course, has a function as a layer to prevent the intrusion of fines from the subgrade into the upper base course and acts as the initial structure to ensure the pavement construction work runs smoothly, and (iv) Subgrade course, serves as the ground to support the above road pavement structures construction.

1.1 Design Life

Pavement design life is an estimated period in which the constructed pavement is able to bear traffic loads before it needs reconstruction [8]. The decreasing level of road service due to increasing service life and traffic growth will aggravate the road structure damages to a higher degree, causing inadequate service to accommodate the existing traffic growth if no rehabilitation of the road structure takes place.

1.2 Pavement Performance Level

The level of road pavement service can be determined by using the Pavement Condition Index (PCI) method. PCI is a visual survey method to rate the types of failure located on the road surface [14].

Table 1 - PCI Scale [14]

Condition	PCI
Excellent	85 – 100
Very Good	70 – 85
Good	55 – 70
Fair	40 – 55
Poor	25 – 40
Very Poor	10 – 25
Failed	0 – 10

1.3 Road Pavement Structure Damage

Damages on flexible pavement are due to several factors, including traffic, water exposure, pavement construction materials, climate, subgrade factors, planning and implementation, and soil compaction processes [11].

1.4 Overlay

Overlay construction is performed to repair and improve the functional and structural conditions of a pavement.

1.5 Benkelman Beam

Benkelman beam is a tool which is mainly used to measure the deflection of a flexible road pavement on an overlay design, which principally works by giving a static load on a single wheel single-axle vehicle. When the deflection occurs, it will be directly transmitted to the benkelman beam, and afterward, the deflection's magnitude will be read by an integrated Benkelman measuring watch [15]. A road evaluation which uses the Benkelman beam is considered to be a non-destructive road pavement evaluation tool [2].

According to the Indonesian National Standard (SNI) 2416: 2011, a deflection test which uses the Benkelman Beam tool will generally undergo 3 types of measurement, namely: (i) Maximum rebound deflection, is the value when the load is moving as far as 6 m from the testing point, (ii) Rebound deflection turning point, is the value when the load is moving as far as 0.30 m (for asbuton and laburan) and 0.40 m (for asphalt concrete), and (iii) Deflection basin, is a curve which illustrates the deflection shape of a road pavement segment as a result of an applied testing load. In this research, banklemen beam chosen because it is easy to use, very effective for determining the strength of the structure without causing damage road surface.

1.6 Overlay Design with Rebound Deflection Method by using Benkelman Beam Tool

Overlay work is performed to restore as well as to improve the functional and structural conditions of road pavement [8]. This particular road pavement overlay design uses the Bina Marga guidelines (Pd T-05-2005-B) (Bina Marga, 2005) and is based on the data obtained with the Benkelman beam. The flexible pavement overlay design has several calculation stages, namely:

a) Determining the Cumulative Equivalent Axle Load (CESA)
   - Total number of lanes and vehicle distribution coefficient (C). The vehicle distribution coefficient values (C) are provided in Table 2.
   - Equivalent Axle Load Factors(E). The equivalent number (E) of each vehicle axle load group can be measured by using Eq. (1) to Eq. (4).
   - Design Life and Traffic Growth Rate (N). The design life and traffic growth rate relationship value (N) can be measured by Eq (5).

- Cumulative Equivalent Axle Load (CESA). The CESA value can be calculated by Eq. (6).

Table 2- Coefficient distribution of vehicle (C) [4]

Number of Lanes	Light vehicle*)		Heavy vehicle**)	
	1	2	1	2
1	1,00	1,00	1,00	1,00
2	0,60	0,50	0,70	0,50
3	0,40	0,40	0,50	0,47
4	-	0,30	-	0,45
5	-	0,25	-	0,42
6	-	0,20	-	0,40

Note: *) Passenger car, **) Truck and Bus

$$E\ SWSA = (AL/5{,}40)^4 \quad (1)$$

$$E\ SWDA = (AL/8{,}16)^4 \quad (2)$$

$$E\ DWDT = (AL/13{,}76)^4 \quad (3)$$

$$E\ DWTT = (AL/18.45)^4 \quad (4)$$

$$N = \frac{1}{2}\left[1+(1+r)^2+2(1+r)\right]\frac{(1+r)^{n-1}-1}{r} \quad (5)$$

$$CESA = \sum m \times 365 \times E \times C \times N \quad (6)$$

where: SWSA = Single wheel single-axel, SWDA = Single wheel dual-axel, DWDT = Dual wheel dual tandem-axle, DWTT = Dual wheel triple tandem-axle, AL = Axle load (tons), N = Design life and traffic growth rate relationship factor, n = Design life, r = Traffic growth rate, CESA = Cumulative Equivalent Axle Load, m = Number of vehicle, 365 = Days in a year, E = Equivalent axle load, C = Coefficient of distributed vehicles, N = Design life and traffic growth rate relationship factor.

b) Rebound Deflection Value Calculation with the Benkelman Beam. Rebound deflection value can be calculated with the following equation.

$$d_B = 2 \times (d_3 - d_1) \times F_t \times C_a \times FK_{B\text{-}BB} \quad (7)$$

where d_B = Rebound deflection value (mm), d_1 = Deflection value when the load is at the initial testing point (mm), d_3 = Deflection value when the load at the distance 6 m form the initial testing point (mm), C_a = Seasonal Factor (1,20 is for the dry season and 0,9 is for the wet season), $FK_{B\text{-}BB}$ = Test load correction factor, BB = 77,343x(load(ton))$^{(-2,0715)}$. F_t = Deflection adjustment factor under standard temperature on 35ºC can be measured by Eq. (8) and Eq. (9) depending on the pavement thickness (HL).

$$F_t = 4{,}184 \times T_L^{-0{,}4025} \text{ for } H_L < 10 \text{ cm} \quad (8)$$

$$F_t = 14{,}785 \times T_L^{-0{,}7573} \text{ for } H_L \geq 10 \text{ cm} \quad (9)$$

$$T_L = 1/3 \times (T_p + T_t + T_b) \quad (10)$$

where: T_p = Surface temperature, T_t = Middle base temperature, T_b = Ground base temperature.

c) Calculating Deflection Uniformity (FK). Deflection uniformity (FK) can be measured with Eq. (11).

$$FK = (s/d_R) \times 100\% < FK_{ijin} \quad (11)$$

where: FK = Uniformity factor, FK_{ijin} = Accepted uniformity factor which is 0 - 10% (very good), 11 – 20% (good), 21 – 30% (fair), d_R = Average deflection (refer Eq. (12), s = Standard deviation (refer Eq. (13)).

$$d_R = \frac{\sum_1^{n_s} d}{n_s} \quad (12)$$

$$s = \sqrt{\frac{n_s\left(\sum_1^{n_s} d^2\right) - \left(\sum_1^{n_s} d\right)^2}{n_s(n_s-1)}} \quad (13)$$

d) Calculating Representative Deflection ($D_{representative}$). Representative deflection value ($D_{representative}$) can be measured by using Eq. (14) to Eq. (16) depending on the function of the road.

$$D_{representative}\ (\text{Arterial}) = d_R + 2s \quad (14)$$

$$D_{representative}\ (\text{Collector}) = d_R + 1{,}64s \quad (15)$$

$$D_{representative}\ (\text{Local}) = d_R + 1{,}28s \quad (16)$$

where: $D_{representative}$ = Representative deflection, d_R = Average deflection, s = Standard deviation.

e) Calculating Design Deflection (D_{design}). Design deflection value (D_{design}) can be measured with Eq. (17).

$$D_{design} = 22{,}208 \text{ x } CESA^{(-0{,}2307)} \quad (17)$$

where: D_{design}= Design deflection (mm), CESA = Cumulative Equivalent Axle Load (ESA).

f) Calculating Overlay Thickness before Correction (H_o). Overlay thickness before correction value (H_o) can be measured with Eq. (18).

$$H_o = \frac{\left[L_n\left(1{,}0364\right) + L_n\left(D_{sblov}\right) - L_n\left(D_{stblov}\right)\right]}{0{,}0597} \quad (18)$$

where: H_o = Overlay thickness before correction (cm), D_{sblov} = $D_{representative}$ (mm), D_{stlov} = D_{design} (mm).

g) Calculating corrected overlay thickness (H_t). Corrected overlay thickness value (H_t) can be measured with Eq. (20).

$$F_o = 0{,}5032 \text{ x } EXP^{(0{,}0194 \text{ x } TPRT)} \quad (19)$$

$$H_t = H_o \text{ x } F_o \quad (20)$$

where: F_o = Pavement thickness correction factor, TPRT = Annually average pavement temperature, H_t = Corrected overlay thickness (cm), H_o = Overlay thickness before corrected (cm), F_o = Pavement thickness correction factor.

h) Correction Factor for Adjustment Overlay Thickness (FK_{TBL}). According to Bina Marga Manual Guidance [4]-[6], the pavement material has been determined which is laston (asphalt concrete) with Resilient Modulus (MR) of 2000 MPa and the Marshall Stability is at least 800 kg. Laston is a composite asphalt with continuous graded aggregates. If another type of asphalt is used (other than Laston), for example, lataston (hot rolled sheet) or modified laston, the adjustment overlay thickness correction factor value needs to be adjusted. Lataston is a dense composite asphalt with gap-graded aggregates, while Laston Modification is modified asphalt mixed with continuous graded aggregates, such as polymer asphalt. The value of adjustment overlay thickness correction factor can be calculated with Eq. (21).

$$FK_{TBL} = 12{,}51 \text{ x } M_R^{(-0{,}333)} \quad (21)$$

where: FK_{TBL} = Overlay thickness correction factor, M_R = Resilient Modulus (MPa).

2. Methodological Framework

2.1 Research Design and Approach

This field research was conducted using a qualitative approach, with a problem identification approach. To identify the research problems, the researcher examined the poor to very poor condition of the road which causes the deterioration on the pavement structure. This particular research used rebound deflection method with the Benkelman Beam which is based on the Bina Marga regulation [4].

2.2 Data Source and Data Collection Methods

This particular study consists of two data sources, namely: (i) Primary data that involve average daily traffic data, deflection data (d_1, d_2, d_3) and temperature data (T_u, T_p), and (ii) Secondary data that involve traffic growth rate, thickness and types of road pavement data, PCI data. In the first year of the research implementation, the primary data collection was planned to be performed for six and a half months from April 2018 to mid-August 2018. The data were collected by means of interview and they were organized into groups, themes and specific problem identification. Therefore, all obtain data should be reduced and grouped specifically. The reduced data were then presented to be understood and analyzed for problem identification. Once the analysis was completed, the researcher drew a conclusion highlighting some alternative solutions of the identified problems.

2.3 Research Location

The research location is situated on Triwidadi road section Sta.14 + 000 - Sta.18 + 000, Pajangan, Bantul, special region of Yogyakarta province, Indonesia. The location is illustrated in Fig. (2) to Fig. (5).

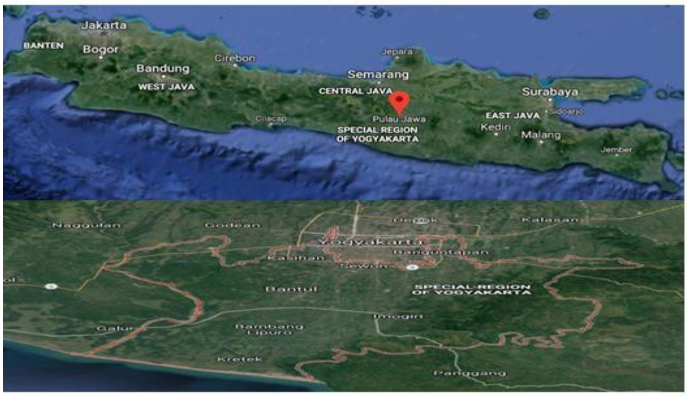


Fig. 2 - Research location in Bantul, Special Region of Yogyakarta Province, Indonesia

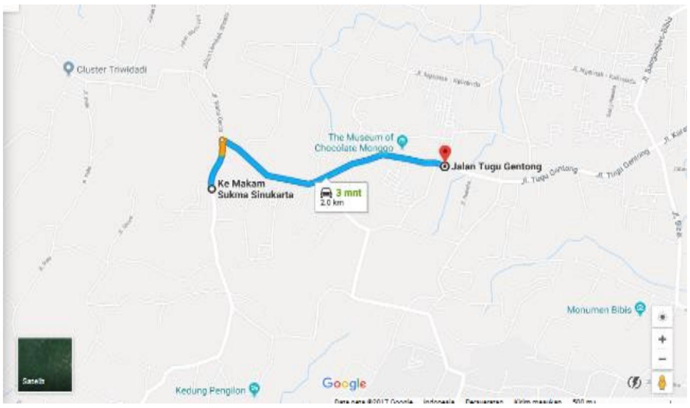


Fig. 3 - Research location in Triwidadi road section, Pajangan, Bantul

Fig. 4 - Research location in Triwidadi road section, Pajangan, Bantul

3. Results and Discussions

This particular research was conducted on Triwidadi road section Sta. 14 + 000 - Sta. 18 + 000. Complete information about the testing location is provided in Table 3.

3.1 CESA Value

The CESA value used on the Triwidadi road section overlay planning is 1,480,000 ESA.

3.2 Traffic Growth Rate Data

Traffic growth rate data was obtained from Road & Traffic Authority (SAMSAT) of Bantul Regency. The traffic growth rate data is presented in Table 4. The table shows the number of vehicle volume and it grower over the year start from 2014 to 2017. It can be easily seen that in 2015, the vehicle volume had a large number compare other years. The most interesting feature is in 2016 had a lower of vehicle volume.

Table 3 - Triwidadi road section information

Attribute	Information
Road Name	Triwidadi
Location	Pajangan, Bantul, Special Region of Yogyakarta Province, Indonesia
Testing Point	Sta.14 + 000 – Sta.18 + 000
Pavement Thickness	± 6 cm
Pavement's Type	*AC-BC*
Pavement Width	± 5 m
Road's Type	2/2 Undevided
Road's Status	Regional Road
Road Function Classification	Local Road
Road Terrain Classification	Hilly
Median	None

Table 4 - Traffic growth rate

Yea	Vehicle	i
201	354238	-
201	373290	5,4
201	391489	4,9
201	404421	3,3
2017	423429	4,7

3.3 Deflection Data

Deflection data were obtained by using the Benkelman beam on Triwidadi road section at Sta.14 + 000 - Sta.18 + 000 with a range between testing points as far as 50 m and made as many as 20 segments (1 segment consists of 4 testing points). Deflection data of the testing results are provided in Table 5.

Table 5 - Deflection testing data

Section	Sta.	Testing load (tonne)	Rebound Deflection (mm)			Temp (℃)	
			d_1	d_2	d_3	T_u	T_p
1	14+000	10,3	0	0,10	0,29	29	31
	14+050	10,3	0	0,35	0,41	29	31
	14+100	10,3	0	0,31	0,39	29	31
	14+150	10,3	0	0,27	0,32	29	31
2	14+200	10,3	0	0,31	0,46	30	36
	14+250	10,3	0	0,21	0,30	30	38
	14+300	10,3	0	0,25	0,33	30	39
	14+350	10,3	0	0,32	0,42	30	39
3	14+400	10,3	0	0,25	0,33	30	39
	14+450	10,3	0	0,24	0,28	30	42
	14+500	10,3	0	0,22	0,28	30	41
	14+550	10,3	0	0,35	0,37	30	41
4	14+600	10,3	0	0,29	0,34	30	41
	14+650	10,3	0	0,31	0,41	30	41
	14+700	10,3	0	0,19	0,29	30	39
	14+750	10,3	0	0,28	0,32	30	36
5	14+800	10,3	0	0,27	0,36	30	36
	14+850	10,3	0	0,24	0,32	30	36
	14+900	10,3	0	0,17	0,25	30	36
	14+950	10,3	0	0,26	0,32	31	36
6	15+000	10,3	0	0,16	0,25	31	36
	15+050	10,3	0	0,21	0,32	31	36
	15+100	10,3	0	0,24	0,37	31	34
	15+150	10,3	0	0,25	0,31	31	34
7	15+200	10,3	0	0,20	0,26	31	34
	15+250	10,3	0	0,20	0,41	31	34
	15+300	10,3	0	0,28	0,39	30	35
	15+350	10,3	0	0,32	0,38	30	35
8	15+400	10,3	0	0,24	0,29	30	35

Section	Sta.	Testing load (tonne)	Rebound Deflection (mm)			Temp (°C)	
			d_1	d_2	d_3	T_u	T_p
	15+450	10,3	0	0,23	0,30	30	35
	15+500	10,3	0	0,09	0,16	31	35
	15+550	10,3	0	0,09	0,15	31	35
9	15+600	10,3	0	0,38	0,48	31	36
	15+650	10,3	0	0,18	0,25	31	36
	15+700	10,3	0	0,25	0,35	30	36
	15+750	10,3	0	0,15	0,25	30	36
10	15+800	10,3	0	0,20	0,40	30	36
	15+850	10,3	0	0,48	0,66	30	36
	15+900	10,3	0	0,46	0,65	30	37
	15+950	10,3	0	0,40	0,58	30	37
11	16+000	10,3	0	0,22	0,28	30	37
	16+050	10,3	0	0,48	0,63	30	35
	16+100	10,3	0	0,37	0,52	30	35
	16+150	10,3	0	0,30	0,41	30	35
12	16+200	10,3	0	0,26	0,40	30	35
	16+250	10,3	0	0,20	0,35	30	34
	16+300	10,3	0	0,40	0,53	30	34
	16+350	10,3	0	0,29	0,52	30	33
13	16+400	10,3	0	0,25	0,41	30	33
	16+450	10,3	0	0,50	0,61	30	32
	16+500	10,3	0	0,28	0,44	30	33
	16+550	10,3	0	0,23	0,44	30	34
14	16+600	10,3	0	0,40	0,48	31	34
	16+650	10,3	0	0,44	0,59	31	34
	16+700	10,3	0	0,33	0,56	31	34
	16+750	10,3	0	0,35	0,56	31	34
15	16+800	10,3	0	0,45	0,76	31	34
	16+850	10,3	0	0,63	0,79	31	34
	16+900	10,3	0	0,42	0,50	31	35
	16+950	10,3	0	0,47	0,51	31	34
16	17+000	10,3	0	0,19	0,40	31	35
	17+050	10,3	0	0,15	0,31	31	35
	17+100	10,3	0	0,20	0,40	31	35
	17+150	10,3	0	0,22	0,39	31	35
17	17+200	10,3	0	0,30	0,44	31	35
	17+250	10,3	0	0,22	0,36	31	35
	17+300	10,3	0	0,32	0,50	29	35
	17+350	10,3	0	0,21	0,39	29	35
18	17+400	10,3	0	0,21	0,38	29	35
	17+450	10,3	0	0,32	0,41	29	35
	17+500	10,3	0	0,24	0,36	29	35
	17+550	10,3	0	0,42	0,56	29	34
19	17+600	10,3	0	0,28	0,41	29	34
	17+650	10,3	0	0,22	0,29	29	35
	17+700	10,3	0	0,25	0,39	29	35
	17+750	10,3	0	0,25	0,33	29	35
20	17+800	10,3	0	0,58	0,71	29	34
	17+850	10,3	0	0,58	0,74	29	34
	17+900	10,3	0	0,50	0,63	29	34
	17+950	10,3	0	0,44	0,56	29	34

Table 5 summarizes information related to deflection of testing data starting from sta.14+000 to 17+950 with variation of testing loads at about 10,3 tones, rebound deflection result (mm), and temperature (^{0}C) around location of survey. The most forminent feature was seen in section 15 which had the largest rebound deflection of about 0,63 (d_2) and 0,79 (d_2). Another interesting feature was apparent in section 3 which had the largest temperature with about 42^{0}C as compared with other sections. Apart from using the Benkelman beam method, this study also uses the PCI method to perform the functional road deterioration assessments. PCI results of Triwidadi road section Sta. 14 + 000 - Sta. 18 + 000 are presented in Table 6.

From Table 6, it can be seen the condition of functional road on Triwidadi street. At the station 15+200 to 15+000, 16+000-17+000, and 17+600-17+800 the index condition respectively shows very poor condition. Besides that, seven different stations also show poor condition, while several other stations indicate fair condition.

Table 6 - PCI calculation on Triwidadi road section at Sta. 14+000 – Sta. 18+000

ST	CDV	100-	P
14+000 –	40,75	40,75	F
14+200 –	5	5	F
14+400 –	4	4	F
14+600 –	47,25	47,25	F
14+800 –	4	4	F
15+000 –	34	34,5	Poor
15+200 –	1	1	Very
15+400 –	18	18,5	Very
15+600 –	5	5	F
15+800 –	26,25	26,25	Poor
16+000 –	25,25	25,25	Poor
16+200 –	53,25	53,25	F
16+400 –	56,75	56,75	F
16+600 –	34,75	34,75	Poor
16+800 –	16,75	16,75	Very
17+000 –	2	2	Poor
17+200 –	41,25	41,25	F
17+400 –	25	25,5	Poor
17+600 –	21,75	21,75	Very
17+800 – 18+000	26,5	26,5	Poor

3.4 Data Analysis

In traffic data analysis, the cumulative equivalent axle load (CESA) value for a 10-year design life was calculated starting from the initial year of usage in 2019 to the final year of usage in 2029 with a traffic growth rate of 4.7%. In order to obtain the LHR value in the year 2019, the researcher conducted measurement using the following formula LHRn = LHRo x (1 + i) n. Analysis of the deflection data results using Bina Marga manual guidelines [4] can be seen in Table 7, 8, and 9, as well as in Fig. (5) and Fig. (6). Table 7 displays the deflection on 20 segments of Triwidadi street. The most striking feature is the highest number in average deflection at segment 20 of about 0,7307 mm. In addition, the standard deviation on segment 15 is also pretty significant with about 0,1730. It is noticeable that segment 8 has the highest percentage in uniformity factor with about 32,688% and segment 15 has a maximum representative deflection with about 0,9229 mm.

Table 7 - Deflection analysis results on Triwidadi road section at Sta.14 + 000 - Sta.18 + 000

Segme	d_R	S	FK	$D_{representative}$	D_{esign}
1	0,400	0,064	16,110	0,48	0,8376
2	0,408	0,082	20,539	0,51	0,8376
3	0,341	0,057	16,772	0,41	0,8376
4	0,359	0,506	14,050	0,42	0,8376
5	0,338	0,049	14,629	0,40	0,8376
6	0,340	0,055	16,327	0,41	0,8376
7	0,394	0,074	18,790	0,48	0,8376
8	0,246	0,089	36,332	0,36	0,8376
9	0,360	0,117	32,688	0,51	0,8376
1	0,618	0,129	20,918	0,78	0,8376
1	0,501	0,165	33,033	0,71	0,8376
1	0,496	0,100	20,167	0,52	0,8376
1	0,528	0,104	19,781	0,66	0,8376
1	0,601	0,051	8,6155	0,66	0,8376
1	0,701	0,173	24,664	0,92	0,8376
1	0,408	0,047	11,623	0,46	0,8376
1	0,470	0,102	21,681	0,60	0,8376
1	0,390	0,061	15,797	0,46	0,8376
20	0,7307	0,0899	12,3091	0,8459	0,8376

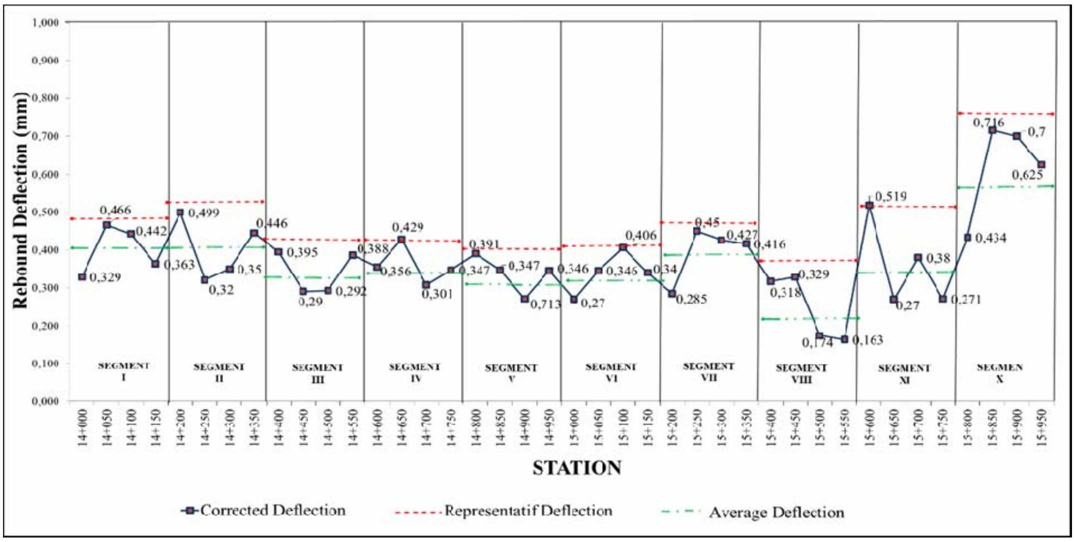


Fig. 5 - Deflection analysis results on Triwidadi road section at Sta.14+000 – Sta.15+950

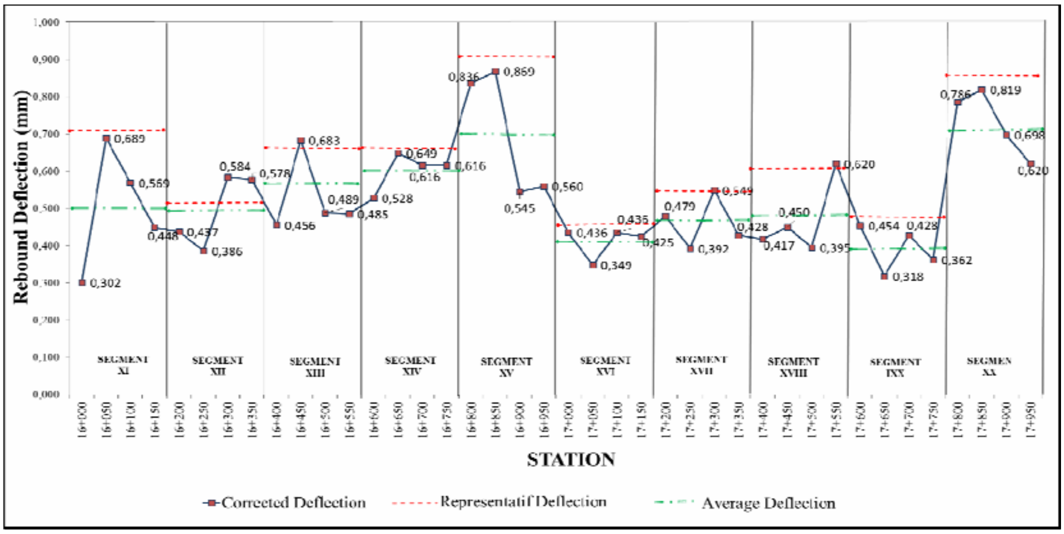


Fig. 6 - Deflection analysis results on Triwidadi road section at Sta.16+000 – Sta.17+950

Table 8 displays results of overlay analysis on Triwidadi Sta.14+000 – Sta.18+000. It can be easily seen from the table that the results from road testing using Banklemen Beam shows negative result in 18 segments, while two segments, namely segment 15 and 20, show positive numbers. Negative numbers indicate that the road pavement does not require any overlay and the structure is still able to bear the load. However, the resulted positive numbers are still relatively small, as they are below 4 cm. This means that the road section requires overlay to support structural performance to be able to support the vehicle load passing.

Table 9 shows the relationship between PCI visually in the field with the additional overlay requirements derived from the calculation results as well as recommendations for overlay on the road sections reviewed. It is clear that the relationships are not always positive as shown by some segments above. Index fair on PCI result shows a negative relationship. Another side index fair on the road pavement are still damaged, but it does not seem to require overlay.

Interestingly PCI results are very poor in segments 7,8 and 19, since they clearly indicate that these roads are damaged, but the experiments using Benklemen does not indicate that it requires overlay and actually very small results, with about -14. Another noteworthy point from the table, is that positive linear correlation is indicated by segments 15 and 20, where the results of the identification tests require overlay about 1 and 2 cm, with the very poor and poor index of PCI. It is clearly shown that between functional damage the damage is also found on the road structure.

PCI results in the table shows that there are a lot of damages occurring on the road. Thus, to simplify the implementation it is recommended to overlay the structure with the smallest thickness level of 4cm. This is expected to improve the surface layer of the Triwidadi road segment, so that it is convenient to use. Pavement evaluation is carried out to determine the existing condition of pavements in terms of its surface and structural adequacy. According to [13], the data obtained from such studies are used for deciding the type of maintenance operations required, for prioritizing maintenance works and for establishing a pavement maintenance management system.

Table 8 - Overlay analysis results on Triwidadi road section Sta.14+000 – Sta.18+000

Segment	Asphalt Pavement Typ	Marshall Stability (k	M_R (Mp	FK_{TBL}	H_o (c	H_t (c	Overlay Thickness (c
1	Asphalt Cement	8	2000	1,0	-	-	-
2	Asphalt Cement	8	2000	1,0	-	-	-
3	Asphalt Cement	8	2000	1,0	- 11,17	- 11,1	- 1
4	Asphalt Cement	8	2000	1,0	- 10,78	- 10,8	- 1
5	Asphalt Cement	8	2000	1,0	- 11,68	- 11,7	- 1
6	Asphalt Cement	8	2000	1,0	- 11,29	- 11,3	- 1
7	Asphalt Cement	8	2000	1,0	-	-	-
8	Asphalt Cement	8	2000	1,0	- 13,52	- 13,5	- 1
9	Asphalt Cement	8	2000	1,0	-	-	-
10	Asphalt Cement	8	2000	1,0	-	-	-
11	Asphalt Cement	8	2000	1,0	-	-	-
12	Asphalt Cement	8	2000	1,0	-	-	-
13	Asphalt Cement	8	2000	1,0	-	-	-
14	Asphalt Cement	8	2000	1,0	-	-	-
15	Asphalt Cement	8	2000	1,0	2,223	2,229	2
16	Asphalt Cement	8	2000	1,0	-	-	-
17	Asphalt Cement	8	2000	1,0	-	-	-
18	Asphalt Cement	8	2000	1,0	-	-	-
19	Asphalt Cement	8	2000	1,0	-	-	-
20	Asphalt Cement	8	2000	1,0	0,764	0,765	1

Table 9 - Correlation of functional road pavement (PCI) results and structural road pavement (Benkelman Beam) results and recommendation for overlay thickness on Triwidadi road section at Sta. 14 + 000 - Sta. 18 + 000

Segment	Station	PCI	*Benkelman Beam* Result Final Overlay Thickness	Recommendation
1	14+000 -	Fair	-	4
2	14+200 -	Fair	-	4
3	14+400 -	Fair	-	4
4	14+600 -	Fair	-	4
5	14+800 -	Fair	-	4
6	15+000 -	Poor	-	4
7	15+200 -	Very Poor	-	4
8	15+400 -	Very Poor	-	4
9	15+600 -	Fair	-	4
1	15+800 -	Fair	-	4
1	16+000 -	Poor	-	4
1	16+200 -	Fair	-	4
1	16+400 -	Fair	-	4
1	16+600 -	Poor	-	4
1	16+800 -	Very Poor	2	4
1	17+000 -	Poor	-	4
1	17+200 -	Fair	-	4
1	17+400 -	Poor	-	4
1	17+600 -	Very Poor	-	4
20	17+800 - 18+000	Poor	1	4

In terms of its relation to the estimated need for treatment and rehabilitation of roads, it is easier to predict the pavement remaining life based on functional failure than those based on structural failure. PCI value may help to identify the segment, which requires a preventive maintenance in order to prevent the further deterioration. The critical limit value of PCI could be determined to select the right time of road handling for segment examined. Based on the critical limitation, the graph is developed to predict the remaining service life based on PCI values [12]. It can be stated that PCI value are suitable for assessment of handling the correct time if the road is damage. To ensure the comfort of road users and related to the age of pavement, any damage must be immediately followed up with functional damage repair to maintain the structure.

4. Conclusion

Based on the analysis, it can be concluded that the recommended solution to offer for overlay design with rebound deflection method using the Benkelman Beam on Triwidadi road section from Sta. 14 + 000 to Sta. 18 + 000 is by selecting asphalt concrete pavement type, with Resilient Modulus (MR) = 2000 MPa, Marshall Stability = 800 kg, correction factor for adjustment overlay thickness = 1.00, and overlay thickness = 4 cm. Pavement with high PCI does not necessarily require rehabilitation of overlays. However, for road users' safety and comfort it, must be consider having smooth functional layer as indicated by the results that are not always significantly positive with the need for overlay.

References

[1] AASHTO, Guide for Design of Pavement Structures, Washington D.C., (1993).

[2] Aji, A. H. F., Subagio, B. S., Hariyadi, E. S., and Weningtyas, W., Evaluasi Struktural Perkerasan Lentur menggunakan Metode AASHTO 1993 and Metode Bina Marga 2013 Studi Kasus: Jalan Nasional Losari – Cirebon. Jurnal Teknik Sipil, Volume 22, (2015), pp. 147-164.

[3] Badan Standarisasi Nasional, Cara Uji Lendutan Perkerasan Lentur dengan Alat Benkelman Beam SNI 2416-2011, Jakarta, (2011).

[4] Bina Marga, Perencanaan Tebal Lapis Tambahan Perkerasan Lentur dengan Metode Lendutan Pd T-05-2005-B, Jakarta, (2005).

[5] Bina Marga, Desain Perkerasan Jalan Lentur No. 002/P/BM/2011, Jakarta, (2011).

[6] Bina Marga, Manual Desain Perkerasan Jalan No. 02/M/BM/2013, Jakarta, (2013).

[7] Hardiyatmo, H. C., Pemeliharaan Jalan Raya, Edisi ke 2, Yogyakarta: Gadjah Mada University Press, (2015).

[8] Hardwiyono, S., Pengaruh Perubahan Suhu pada Modulus Elastik Lapisan Beraspal Perkerasan Lentur dalam Pengujian Regangan yang Berbeda. Jurnal Ilmiah Semesta Teknika, Volume 14, (2011), pp. 72-80.

[9] Hardwiyono,S., Metode Pelaksanaan Perkerasan Jalan, Yogyakarta: LP3M Universitas Muhamma-diyah Yogyakarta, (2013).

[10] Morisca, W., Evaluasi Beban Kendaraan terhadap Derajat Kerusakan and Umur sisa Jalan (Studi Kasus: PPT. Simpang Nibung and PPT. Merapi Sumatera Selatan). Jurnal Teknik Sipil and Lingkungan, Volume 2, (2014), pp. 692-699.

[11] Sari, D. N., Analisa Beban Kendaraan terhadap Derajat Kerusakan Jalan and Umur Sisa. Jurnal Teknik Sipil and Lingkungan, Volume 2(4), 615-620, (2014).

[12] Setyawan, Ari., Jolis, Nainggolan., Arif, Budiantoro., Predicting the Remaining Service Life of Road Using Pavement Condition Index. Journal Procedia Engineering, Volume 25, (2015), pp. 417-423.

[13] Solanki, Ujjval J., Pradip J. Gundalia., Mansukh D. Barasara., A Review on Structural Evaluation of Flexible Pavements using Falling Weight Deflectometer. Journal of Trends in Transport Engineering and Applications, Volume 2, (2015), pp. 1-10.

[14] Tho'atin, U., Setyawan, A., and Suprapto, M., Penggunaan Metode International Roughness Index (IRI), Surface Distress Index (SDI), and Pavement Condition Index (PCI) untuk Penilaian Kondisi Jalan di Kabupaten Wonogiri. Seminar Nasional Sains and Teknologi, Jakarta, 8 November ,(2016), pp. 10-18.

[15] Wicaksono, A.N., Perencanaan Tebal Lapis Tambah Metode Pd T-05-2005-B and Metode SDPJL pada Jalan Nasional di Yogyakarta. Jurnal Matriks Teknik Sipil, Volume 5, (2017), pp. 623-631.

Rehabilitation Planning for Flexible Pavement using Rebound

by Nternational Journal Ofintegratedengineering Vol.11 No. 9 (2019)

INTERNATIONAL JOURNAL OF INTEGRATED ENGINEERING VOL. 11 NO. 9 (2019) 201–211

IJIE

Journal homepage: http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN : 2229-838X e-ISSN : 2600-7916

The International Journal of Integrated Engineering

Rehabilitation Planning for Flexible Pavement using Rebound Deflection Method and PCI Method on Triwidadi Road of Yogyakarta

Emil Adly[1,*], Wahyu Widodo[1], Anita Rahmawati[1], J. N. N. R. Sri Atmaja Putra[1]

[1]Department of Civil Engineering, Faculty of Engineering,
Universitas Muhammadiyah Yogyakarta, Daerah Istimewa Yogyakarta 55183, INDONESIA

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2019.11.09.022
Received 21 February 2019; Accepted 16 October 2019; Available online 31 December 2019

Abstract: Triwidadi Road, located in the Pajangan area, Bantul, Special Region of Yogyakarta Province in Indonesia is characterised as local road in accordance to its function, and is classified as poor category based upon the PCI results. Damages scattered on the road section often cause an uncomfortable feeling of the road users, and may also potentially cause traffic accidents. An overlay addition is considered to be a solutive alternative to improve the road pavement structure in order to ensure its appropriateness and service quality to the road users. This study uses the rebound deflection method with the Benkelman Beam which is based on the Pd T-05-2005-B regulation. The studied road was 4 km long, stationing at 14+000 - 18+000 with 50 meters range between one tested point to another, and was made as many as 20 segments. The results show that there is no significant correlation between functional layer damages with the structural road, which is shown from the comparison between data analysis with PCI result which stating the corrected overlay, hence recommendation solutions that can be offered to be performed are as follows: overlay addition for all segments are 4 cm, with Laston asphalt type with Resilient Modulus = 2000 MPa and Marshall Stability = 800 kg for a 10-year design life with CESA = 1,480,000 ESA.

Keywords: Benkelman Beam, Overlay, Pavement Condition Index, Rebound Deflection Method

1. Introduction

Being a local road receiving only little attention from the local government, the Triwidadi Road located in the Pajangan area, Bantul, Special Region of Yogyakarta is severely damaged and destroyed. The damaged road leads to discomfort and dissatisfaction among road users in addition to the threat of potential accidents. Road damages certainly lead to road rage and pose threat to the safety of road users. As a solution to the aforementioned problems, it is necessary for us to conduct an investigation of road deterioration and damages. An overlay addition is considered to be a good alternative to improve the road pavement structure in order to ensure its appropriateness and quality. Thus, this study aims to conduct deflection testing of the Triwidadi Road pavement for an overlay design on the subsequent road's pavement project. In addition, this study is also intended to investigate the correlation between the road functional damages and deflection in the field.

Flexible road pavement is a pavement which uses asphalt as a bonding material and typically consists of 4 layers namely surface course, upper base course, bottom base course, and subgrade course [10]. The functions of each layer are described as follows: (i) Surface course, has a function as a wheeled vehicles load-bearing layer, preventing surface water to enter the underlying structure layers, and serves as the wearing course, (ii) Base course, has a function as a

*Corresponding author: adly_zola@yahoo.com

laying base for the surface course and it provides additional load distribution to descend the traffic load into the bottom base course, (iii) Subbase course, has a function as a layer to prevent the intrusion of fines from the subgrade into the upper base course and acts as the initial structure to ensure the pavement construction work runs smoothly, and (iv) Subgrade course, serves as the ground to support the above road pavement structures construction.

1.1 Design Life

Pavement design life is an estimated period in which the constructed pavement is able to bear traffic loads before it needs reconstruction [8]. The decreasing level of road service due to increasing service life and traffic growth will aggravate the road structure damages to a higher degree, causing inadequate service to accommodate the existing traffic growth if no rehabilitation of the road structure takes place.

1.2 Pavement Performance Level

The level of road pavement service can be determined by using the Pavement Condition Index (PCI) method. PCI is a visual survey method to rate the types of failure located on the road surface [14].

Table 1 - PCI Scale [14]

Condition	PCI
Excellent	85 – 100
Very Good	70 – 85
Good	55 – 70
Fair	40 – 55
Poor	25 – 40
Very Poor	10 – 25
Failed	0 – 10

1.3 Road Pavement Structure Damage

Damages on flexible pavement are due to several factors, including traffic, water exposure, pavement construction materials, climate, subgrade factors, planning and implementation, and soil compaction processes [11].

1.4 Overlay

Overlay construction is performed to repair and improve the functional and structural conditions of a pavement.

1.5 Benkelman Beam

Benkelman beam is a tool which is mainly used to measure the deflection of a flexible road pavement on an overlay design, which principally works by giving a static load on a single wheel single-axle vehicle. When the deflection occurs, it will be directly transmitted to the benkelman beam, and afterward, the deflection's magnitude will be read by an integrated Benkelman measuring watch [15]. A road evaluation which uses the Benkelman beam is considered to be a non-destructive road pavement evaluation tool [2].

According to the Indonesian National Standard (SNI) 2416: 2011, a deflection test which uses the Benkelman Beam tool will generally undergo 3 types of measurement, namely: (i) Maximum rebound deflection, is the value when the load is moving as far as 6 m from the testing point, (ii) Rebound deflection turning point, is the value when the load is moving as far as 0.30 m (for asbuton and laburan) and 0.40 m (for asphalt concrete), and (iii) Deflection basin, is a curve which illustrates the deflection shape of a road pavement segment as a result of an applied testing load. In this research, banklemen beam chosen because it is easy to use, very effective for determining the strength of the structure without causing damage road surface.

1.6 Overlay Design with Rebound Deflection Method by using Benkelman Beam Tool

Overlay work is performed to restore as well as to improve the functional and structural conditions of road pavement [8]. This particular road pavement overlay design uses the Bina Marga guidelines (Pd T-05-2005-B) (Bina Marga, 2005) and is based on the data obtained with the Benkelman beam. The flexible pavement overlay design has several calculation stages, namely:

a) Determining the Cumulative Equivalent Axle Load (CESA)
- Total number of lanes and vehicle distribution coefficient (C). The vehicle distribution coefficient values (C) are provided in Table 2.
- Equivalent Axle Load Factors(E). The equivalent number (E) of each vehicle axle load group can be measured using Eq. (1) to Eq. (4).
- Design Life and Traffic Growth Rate (N). The design life and traffic growth rate relationship value (N) can be measured by Eq (5).

- Cumulative Equivalent Axle Load (CESA). The CESA value can be calculated by Eq. (6).

Table 2- Coefficient distribution of vehicle (C) [4]

Number of Lanes	Light vehicle*)		Heavy vehicle**)	
	1	2	1	2
1	1,00	1,00	1,00	1,00
2	0,60	0,50	0,70	0,50
3	0,40	0,40	0,50	0,47
4	-	0,30	-	0,45
5	-	0,25	-	0,42
6	-	0,20	-	0,40

Note: *) Passenger car, **) Truck and Bus

$$E\ SWSA = (AL/5{,}40)^4 \tag{1}$$

$$E\ SWDA = (AL/8{,}16)^4 \tag{2}$$

$$E\ DWDT = (AL/13{,}76)^4 \tag{3}$$

$$E\ DWTT = (AL/18.45)^4 \tag{4}$$

$$N = \frac{1}{2}\left[1 + (1+r)^2 + 2(1+r)\right]\frac{(1+r)^{n-1} - 1}{r} \tag{5}$$

$$CESA = \sum m \times 365 \times E \times C \times N \tag{6}$$

where: SWSA = Single wheel single-axel, SWDA = Single wheel dual-axel, DWDT = Dual wheel dual tandem-axle, DWTT = Dual wheel triple tandem-axle, AL = Axle load (tons), N = Design life and traffic growth rate relationship factor, n = Design life, r = Traffic growth rate, CESA = Cumulative Equivalent Axle Load, m = Number of vehicle, 365 = Days in a year, E = Equivalent axle load, C = Coefficient of distributed vehicles, N = Design life and traffic growth rate relationship factor.

b) Rebound Deflection Value Calculation with the Benkelman Beam. Rebound deflection value can be calculated with the following equation.

$$d_B = 2\ x\ (d_3 - d_1)\ x\ F_t\ x\ C_a\ x\ FK_{B\text{-}BB} \tag{7}$$

where d_B = Rebound deflection value (mm), d_1 = Deflection value when the load is at the initial testing point (mm), d_3 = Deflection value when the load at the distance 6 m form the initial testing point (mm), C_a = Seasonal Factor (1,20 is for the dry season and 0,9 is for the wet season), $FK_{B\text{-}BB}$ = Test load correction factor, BB = 77,343x(load(ton))$^{(-2,0715)}$. F_t = Deflection adjustment factor under standard temperature on 35^{o}C can be measured by Eq. (8) and Eq. (9) depending on the pavement thickness (HL).

$$F_t = 4{,}184\ x\ T_L^{-0{,}4025}\ \text{for}\ H_L < 10\ \text{cm} \tag{8}$$

$$F_t = 14{,}785\ x\ T_L^{[illegible]}\ \text{for}\ H_L \geq 10\ \text{cm} \tag{9}$$

$$T_L = 1/3\ x\ (T_p + T_t + T_b) \tag{10}$$

where: T_p = Surface temperature, T_t = Middle base temperature, T_b = Ground base temperature.

c) Calculating Deflection Uniformity (FK). Deflection uniformity (FK) can be measured with Eq. (11).

$$FK = (s/d_R)\ x\ 100\% < FK_{ijin} \tag{11}$$

where: FK = Uniformity factor, FK_{ijin} = Accepted uniformity factor which is 0 - 10% (very good), 11 – 20% (good), 21 – 30% (fair), d_R = Average deflection (refer Eq. (12), s = Standard deviation (refer Eq. (13)).

$$d_R = \frac{\sum_1^{n_s} d}{n_s} \tag{12}$$

$$s = \sqrt{\frac{n_s\left(\sum_1^{n_s} d^2\right) - \left(\sum_1^{n_s} d\right)^2}{n_s\,(n_s - 1)}} \tag{13}$$

d) Calculating Representative Deflection ($D_{representative}$). Representative deflection value ($D_{representative}$) can be measured by using Eq. (14) to Eq. (16) depending on the function of the road.

$$D_{representative}\ (\text{Arterial}) = d_R + 2s \tag{14}$$

$$D_{representative}\ (\text{Collector}) = d_R + 1{,}64s \tag{15}$$

$$D_{representative}\ (\text{Local}) = d_R + 1{,}28s \tag{16}$$

where: $D_{representative}$ = Representative deflection, d_R = Average deflection, s = Standard deviation.

e) Calculating Design Deflection (D_{design}). Design deflection value (D_{design}) can be measured with Eq. (17).

$$D_{design} = 22{,}208 \text{ x } CESA^{(-0{,}2307)} \tag{17}$$

where: D_{design} = Design deflection (mm), CESA = Cumulative Equivalent Axle Load (ESA).

f) Calculating Overlay Thickness before Correction (H_o). Overlay thickness before correction value (H_o) can be measured with Eq. (18).

$$H_o = \frac{\left[L_n\left(1{,}0364\right) + L_n\left(D_{sblov}\right) - L_n\left(D_{stblov}\right)\right]}{0{,}0597} \tag{18}$$

where: H_o = Overlay thickness before correction (cm), D_{sblov} = $D_{representative}$ (mm), D_{stlov} = D_{design} (mm).

g) Calculating corrected overlay thickness (H_t). Corrected overlay thickness value (H_t) can be measured with Eq. (20).

$$F_o = 0{,}5032 \text{ x } EXP^{(0{,}0194 \text{ x } TPRT)} \tag{19}$$

$$H_t = H_o \text{ x } F_o \tag{20}$$

where: F_o = Pavement thickness correction factor, TPRT = Annually average pavement temperature, H_t = Corrected overlay thickness (cm), H_o = Overlay thickness before corrected (cm), F_o = Pavement thickness correction factor.

h) Correction Factor for Adjustment Overlay Thickness (FK_{TBL}). According to Bina Marga Manual Guidance [4]-[6], the pavement material has been determined which is laston (asphalt concrete) with Resilient Modulus (MR) of 2000 MPa and the Marshall Stability is at least 800 kg. Laston is a composite asphalt with continuous graded aggregates. If another type of asphalt is used (other than Laston), for example, lataston (hot rolled sheet) or modified laston, the adjustment overlay thickness correction factor value needs to be adjusted. Lataston is a dense composite asphalt with gap-graded aggregates, while Laston Modification is modified asphalt mixed with continuous graded aggregates, such as polymer asphalt. The value of adjustment overlay thickness correction factor can be calculated with Eq. (21).

$$FK_{TBL} = 12{,}51 \text{ x } M_R^{(-0{,}333)} \tag{21}$$

where: FK_{TBL} = Overlay thickness correction factor, M_R = Resilient Modulus (MPa).

2. Methodological Framework

2.1 Research Design and Approach

This field research was conducted using a qualitative approach, with a problem identification approach. To identify the research problems, the researcher examined the poor to very poor condition of the road which causes the deterioration on the pavement structure. This particular research used rebound deflection method with the Benkelman Beam which is based on the Bina Marga regulation [4].

2.2 Data Source and Data Collection Methods

This particular study consists of two data sources, namely: (i) Primary data that involve average daily traffic data, deflection data (d_1, d_2, d_3) and temperature data (T_u, T_p), and (ii) Secondary data that involve traffic growth rate, thickness and types of road pavement data, PCI data. In the first year of the research implementation, the primary data collection was planned to be performed for six and a half months from April 2018 to mid-August 2018. The data were collected by means of interview and they were organized into groups, themes and specific problem identification. Therefore, all obtain data should be reduced and grouped specifically. The reduced data were then presented to be understood and analyzed for problem identification. Once the analysis was completed, the researcher drew a conclusion highlighting some alternative solutions of the identified problems.

2.3 Research Location

The research location is situated on Triwidadi road section Sta.14 + 000 - Sta.18 + 000, Pajangan, Bantul, special region of Yogyakarta province, Indonesia. The location is illustrated in Fig. (2) to Fig. (5).

Fig. 2 - Research location in Bantul, Special Region of Yogyakarta Province, Indonesia

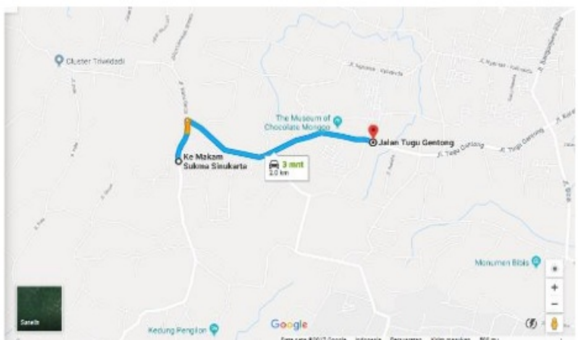


Fig. 3 - Research location in Triwidadi road section, Pajangan, Bantul

Fig. 4 - Research location in Triwidadi road section, Pajangan, Bantul

3. Results and Discussions

This particular research was conducted on Triwidadi road section Sta. 14 + 000 - Sta. 18 + 000. Complete information about the testing location is provided in Table 3.

3.1 CESA Value

The CESA value used on the Triwidadi road section overlay planning is 1,480,000 ESA.

3.2 Traffic Growth Rate Data

Traffic growth rate data was obtained from Road & Traffic Authority (SAMSAT) of Bantul Regency. The traffic growth rate data is presented in Table 4. The table shows the number of vehicle volume and it grower over the year start from 2014 to 2017. It can be easily seen that in 2015, the vehicle volume had a large number compare other years. The most interesting feature is in 2016 had a lower of vehicle volume.

Table 3 - Triwidadi road section information

Attribute	Information
Road Name	Triwidadi
Location	Pajangan, Bantul, Special Region of Yogyakarta Province, Indonesia
Testing Point	Sta.14 + 000 – Sta.18 + 000
Pavement Thickness	± 6 cm
Pavement's Type	*AC-BC*
Pavement Width	± 5 m
Road's Type	2/2 Undevided
Road's Status	Regional Road
Road Function Classification	Local Road
Road Terrain Classification	Hilly
Median	None

Table 4 - Traffic growth rate

Yea	Vehicle	i
201	354238	-
201	373290	5,4
201	391489	4,9
201	404421	3,3
2017	423429	4,7

3.3 Deflection Data

Deflection data were obtained by using the Benkelman beam on Triwidadi road section at Sta.14 + 000 - Sta.18 + 000 with a range between testing points as far as 50 m and made as many as 20 segments (1 segment consists of 4 testing points). Deflection data of the testing results are provided in Table 5.

Table 5 - Deflection testing data

Section	Sta.	Testing load (tonne)	Rebound Deflection (mm)			Temp (℃)	
			d_1	d_2	d_3	T_u	T_p
1	14+000	10,3	0	0,10	0,29	29	31
	14+050	10,3	0	0,35	0,41	29	31
	14+100	10,3	0	0,31	0,39	29	31
	14+150	10,3	0	0,27	0,32	29	31
2	14+200	10,3	0	0,31	0,46	30	36
	14+250	10,3	0	0,21	0,30	30	38
	14+300	10,3	0	0,25	0,33	30	39
	14+350	10,3	0	0,32	0,42	30	39
3	14+400	10,3	0	0,25	0,33	30	39
	14+450	10,3	0	0,24	0,28	30	42
	14+500	10,3	0	0,22	0,28	30	41
	14+550	10,3	0	0,35	0,37	30	41
4	14+600	10,3	0	0,29	0,34	30	41
	14+650	10,3	0	0,31	0,41	30	41
	14+700	10,3	0	0,19	0,29	30	39
	14+750	10,3	0	0,28	0,32	30	36
5	14+800	10,3	0	0,27	0,36	30	36
	14+850	10,3	0	0,24	0,32	30	36
	14+900	10,3	0	0,17	0,25	30	36
	14+950	10,3	0	0,26	0,32	31	36
6	15+000	10,3	0	0,16	0,25	31	36
	15+050	10,3	0	0,21	0,32	31	36
	15+100	10,3	0	0,24	0,37	31	34
	15+150	10,3	0	0,25	0,31	31	34
7	15+200	10,3	0	0,20	0,26	31	34
	15+250	10,3	0	0,20	0,41	31	34
	15+300	10,3	0	0,28	0,39	30	35
	15+350	10,3	0	0,32	0,38	30	35
8	15+400	10,3	0	0,24	0,29	30	35

Section	Sta.	Testing load (tonne)	Rebound Deflection (mm)			Temp (°C)	
			d_1	d_2	d_3	T_u	T_p
	15+450	10,3	0	0,23	0,30	30	35
	15+500	10,3	0	0,09	0,16	31	35
	15+550	10,3	0	0,09	0,15	31	35
9	15+600	10,3	0	0,38	0,48	31	36
	15+650	10,3	0	0,18	0,25	31	36
	15+700	10,3	0	0,25	0,35	30	36
	15+750	10,3	0	0,15	0,25	30	36
10	15+800	10,3	0	0,20	0,40	30	36
	15+850	10,3	0	0,48	0,66	30	36
	15+900	10,3	0	0,46	0,65	30	37
	15+950	10,3	0	0,40	0,58	30	37
11	16+000	10,3	0	0,22	0,28	30	37
	16+050	10,3	0	0,48	0,63	30	35
	16+100	10,3	0	0,37	0,52	30	35
	16+150	10,3	0	0,30	0,41	30	35
12	16+200	10,3	0	0,26	0,40	30	35
	16+250	10,3	0	0,20	0,35	30	34
	16+300	10,3	0	0,40	0,53	30	34
	16+350	10,3	0	0,29	0,52	30	33
13	16+400	10,3	0	0,25	0,41	30	33
	16+450	10,3	0	0,50	0,61	30	32
	16+500	10,3	0	0,28	0,44	30	33
	16+550	10,3	0	0,23	0,44	30	34
14	16+600	10,3	0	0,40	0,48	31	34
	16+650	10,3	0	0,44	0,59	31	34
	16+700	10,3	0	0,33	0,56	31	34
	16+750	10,3	0	0,35	0,56	31	34
15	16+800	10,3	0	0,45	0,76	31	34
	16+850	10,3	0	0,63	0,79	31	34
	16+900	10,3	0	0,42	0,50	31	35
	16+950	10,3	0	0,47	0,51	31	34
16	17+000	10,3	0	0,19	0,40	31	35
	17+050	10,3	0	0,15	0,31	31	35
	17+100	10,3	0	0,20	0,40	31	35
	17+150	10,3	0	0,22	0,39	31	35
17	17+200	10,3	0	0,30	0,44	31	35
	17+250	10,3	0	0,22	0,36	31	35
	17+300	10,3	0	0,32	0,50	29	35
	17+350	10,3	0	0,21	0,39	29	35
18	17+400	10,3	0	0,21	0,38	29	35
	17+450	10,3	0	0,32	0,41	29	35
	17+500	10,3	0	0,24	0,36	29	35
	17+550	10,3	0	0,42	0,56	29	34
19	17+600	10,3	0	0,28	0,41	29	34
	17+650	10,3	0	0,22	0,29	29	35
	17+700	10,3	0	0,25	0,39	29	35
	17+750	10,3	0	0,25	0,33	29	35
20	17+800	10,3	0	0,58	0,71	29	34
	17+850	10,3	0	0,58	0,74	29	34
	17+900	10,3	0	0,50	0,63	29	34
	17+950	10,3	0	0,44	0,56	29	34

Table 5 summarizes information related to deflection of testing data starting from sta.14+000 to 17+950 with variation of testing loads at about 10,3 tones, rebound deflection result (mm), and temperature (^{0}C) around location of survey. The most forminent feature was seen in section 15 which had the largest rebound deflection of about 0,63 (d_2) and 0,79 (d_2). Another interesting feature was apparent in section 3 which had the largest temperature with about 42^{0}C as compared with other sections. Apart from using the Benkelman beam method, this study also uses the PCI method to perform the functional road deterioration assessments. PCI results of Triwidadi road section Sta. 14 + 000 - Sta. 18 + 000 are presented in Table 6.

From Table 6, it can be seen the condition of functional road on Triwidadi street. At the station 15+200 to 15+000, 16+000-17+000, and 17+600-17+800 the index condition respectively shows very poor condition. Besides that, seven different stations also show poor condition, while several other stations indicate fair condition.

Table 6 - PCI calculation on Triwidadi road section at Sta. 14+000 – Sta. 18+000

ST	CDV	100-	
14+000 –	40,75	40,75	F
14+200 –	5	5	F
14+400 –	4	4	F
14+600 –	47,25	47,25	F
14+800 –	4	4	F
15+000 –	34	34,5	Poor
15+200 –	1	1	Very
15+400 –	18	18,5	Very
15+600 –	5	5	F
15+800 –	26,25	26,25	Poor
16+000 –	25,25	25,25	Poor
16+200 –	53,25	53,25	F
16+400 –	56,75	56,75	F
16+600 –	34,75	34,75	Poor
16+800 –	16,75	16,75	Very
17+000 –	2	2	Poor
17+200 –	41,25	41,25	F
17+400 –	25	25,5	Poor
17+600 –	21,75	21,75	Very
17+800 – 18+000	26,5	26,5	Poor

3.4 Data Analysis

In traffic data analysis, the cumulative equivalent axle load (CESA) value for a 10-year design life was calculat starting from the initial year of usage in 2019 to the final year of usage in 2029 with a traffic growth rate of 4.7%. In order to obtain the LHR value in the year 2019, the researcher conducted measurement using the following formula LHRn = LHRo x (1 + i) n. Analysis of the deflection data results using Bina Marga manual guidelines [4] can be seen in Table 7, 8, and 9, as well as in Fig. (5) and Fig. (6). Table 7 displays the deflection on 20 segments of Triwidadi street. The most striking feature is the highest number in average deflection at segment 20 of about 0,7307 mm. In addition, the standard deviation on segment 15 is also pretty significant with about 0,1730. It is noticeable that segment 8 has the highest percentage in uniformity factor with about 32,688% and segment 15 has a maximum representative deflection with about 0,9229 mm.

Table 7 - Deflection analysis results on Triwidadi road section at Sta.14 + 000 - Sta.18 + 000

Segme	d_R	S	FK	$D_{representative}$	D_{esign}
1	0,400	0,064	16,110	0,48	0,8376
2	0,408	0,082	20,539	0,51	0,8376
3	0,341	0,057	16,772	0,41	0,8376
4	0,359	0,506	14,050	0,42	0,8376
5	0,338	0,049	14,629	0,40	0,8376
6	0,340	0,055	16,327	0,41	0,8376
7	0,394	0,074	18,790	0,48	0,8376
8	0,246	0,089	36,332	0,36	0,8376
9	0,360	0,117	32,688	0,51	0,8376
1	0,618	0,129	20,918	0,78	0,8376
1	0,501	0,165	33,033	0,71	0,8376
1	0,496	0,100	20,167	0,52	0,8376
1	0,528	0,104	19,781	0,66	0,8376
1	0,601	0,051	8,6155	0,66	0,8376
1	0,701	0,173	24,664	0,92	0,8376
1	0,408	0,047	11,623	0,46	0,8376
1	0,470	0,102	21,681	0,60	0,8376
1	0,390	0,061	15,797	0,46	0,8376
20	0,7307	0,0899	12,3091	0,8459	0,8376

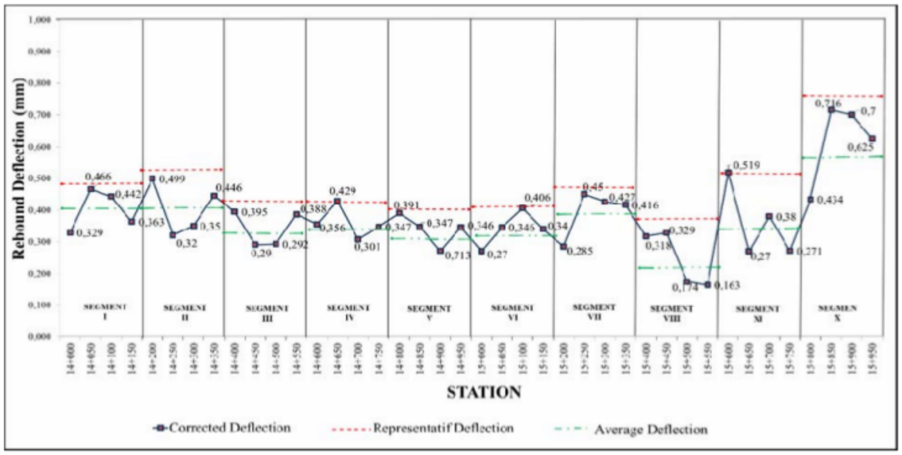


Fig. 5 - Deflection analysis results on Triwidadi road section at Sta.14+000 – Sta.15+950

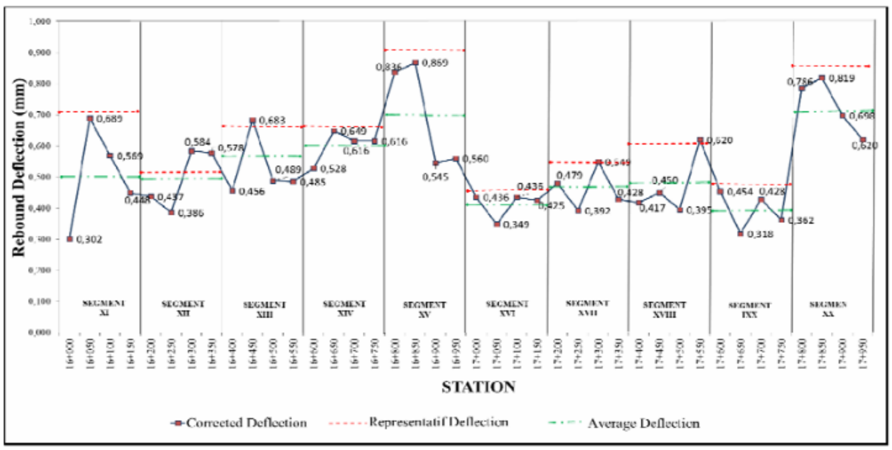


Fig. 6 - Deflection analysis results on Triwidadi road section at Sta.16+000 – Sta.17+950

Table 8 displays results of overlay analysis on Triwidadi Sta.14+000 – Sta.18+000. It can be easily seen from the table that the results from road testing using Banklemen Beam shows negative result in 18 segments, while two segments, namely segment 15 and 20, show positive numbers. Negative numbers indicate that the road pavement does not require any overlay and the structure is still able to bear the load. However, the resulted positive numbers are still relatively small, as they are below 4 cm. This means that the road section requires overlay to support structural performance to be able to support the vehicle load passing.

Table 9 shows the relationship between PCI visually in the field with the additional overlay requirements derived from the calculation results as well as recommendations for overlay on the road sections reviewed. It is clear that the relationships are not always positive as shown by some segments above. Index fair on PCI result shows a negative relationship. Another side index fair on the road pavement are still damaged, but it does not seem to require overlay.

Interestingly PCI results are very poor in segments 7,8 and 19, since they clearly indicate that these roads are damaged, but the experiments using Benklemen does not indicate that it requires overlay and actually very small results, with about -14. Another noteworthy point from the table, is that positive linear correlation is indicated by segments 15 and 20, where the results of the identification tests require overlay about 1 and 2 cm, with the very poor and poor index of PCI. It is clearly shown that between functional damage the damage is also found on the road structure.

PCI results in the table shows that there are a lot of damages occurring on the road. Thus, to simplify the implementation it is recommended to overlay the structure with the smallest thickness level of 4cm. This is expected to improve the surface layer of the Triwidadi road segment, so that it is convenient to use. Pavement evaluation is carried out to determine the existing condition of pavements in terms of its surface and structural adequacy. According to [13], the data obtained from such studies are used for deciding the type of maintenance operations required, for prioritizing maintenance works and for establishing a pavement maintenance management system.

Table 8 - Overlay analysis results on Triwidadi road section Sta.14+000 – Sta.18+000

Segment	Asphalt Pavement Typ	Marshall Stability (k	M_R (Mp	FK_{TBL}	H_o (c	H_t (c	Overlay Thickness (c
1	Asphalt Cement	8	2000	1,0	-	-	-
2	Asphalt Cement	8	2000	1,0	-	-	-
3	Asphalt Cement	8	2000	1,0	-11,17	-11,1	-1
4	Asphalt Cement	8	2000	1,0	-10,78	-10,8	-1
5	Asphalt Cement	8	2000	1,0	-11,68	-11,7	-1
6	Asphalt Cement	8	2000	1,0	-11,29	-11,3	-1
7	Asphalt Cement	8	2000	1,0	-	-	-
8	Asphalt Cement	8	2000	1,0	-13,52	-13,5	-1
9	Asphalt Cement	8	2000	1,0	-	-	-
10	Asphalt Cement	8	2000	1,0	-	-	-
11	Asphalt Cement	8	2000	1,0	-	-	-
12	Asphalt Cement	8	2000	1,0	-	-	-
13	Asphalt Cement	8	2000	1,0	-	-	-
14	Asphalt Cement	8	2000	1,0	-	-	-
15	Asphalt Cement	8	2000	1,0	2,223	2,229	2
16	Asphalt Cement	8	2000	1,0	-	-	-
17	Asphalt Cement	8	2000	1,0	-	-	-
18	Asphalt Cement	8	2000	1,0	-	-	-
19	Asphalt Cement	8	2000	1,0	-	-	-
20	Asphalt Cement	8	2000	1,0	0,764	0,765	1

Table 9 - Correlation of functional road pavement (PCI) results and structural road pavement (Benkelman Beam) results and recommendation for overlay thickness on Triwidadi road section at Sta. 14 + 000 - Sta. 18 + 000

Segment	Station	PCI	*Benkelman Beam* Result Final Overlay Thickness	Recommendation
1	14+000 -	Fair	-	4
2	14+200 -	Fair	-	4
3	14+400 -	Fair	-	4
4	14+600 -	Fair	-	4
5	14+800 -	Fair	-	4
6	15+000 -	Poor	-	4
7	15+200 -	Very Poor	-	4
8	15+400 -	Very Poor	-	4
9	15+600 -	Fair	-	4
1	15+800 -	Fair	-	4
1	16+000 -	Poor	-	4
1	16+200 -	Fair	-	4
1	16+400 -	Fair	-	4
1	16+600 -	Poor	-	4
1	16+800 -	Very Poor	2	4
1	17+000 -	Poor	-	4
1	17+200 -	Fair	-	4
1	17+400 -	Poor	-	4
1	17+600 -	Very Poor	-	4
20	17+800 - 18+000	Poor	1	4

In terms of its relation to the estimated need for treatment and rehabilitation of roads, it is easier to predict the pavement remaining life based on functional failure than those based on structural failure. PCI value may help to identify the segment, which requires a preventive maintenance in order to prevent the further deterioration. The critical limit value of PCI could be determined to select the right time of road handling for segment examined. Based on the critical limitation, the graph is developed to predict the remaining service life based on PCI values [12]. It can be stated that PCI value are suitable for assessment of handling the correct time if the road is damage. To ensure the comfort of road users and related to the age of pavement, any damage must be immediately followed up with functional damage repair to maintain the structure.

4. Conclusion

Based on the analysis, it can be concluded that the recommended solution to offer for overlay design with rebound deflection method using the Benkelman Beam on Triwidadi road section from Sta. 14 + 000 to Sta. 18 + 000 is by selecting asphalt concrete pavement type, with Resilient Modulus (MR) = 2000 MPa, Marshall Stability = 800 kg, correction factor for adjustment overlay thickness = 1.00, and overlay thickness = 4 cm. Pavement with high PCI does not necessarily require rehabilitation of overlays. However, for road users' safety and comfort it, must be consider having smooth functional layer as indicated by the results that are not always significantly positive with the need for overlay.

References

[1] AASHTO, Guide for Design of Pavement Structures, Washington D.C., (1993).

[2] Aji, A. H. F., Subagio, B. S., Hariyadi, E. S., and Weningtyas, W., Evaluasi Struktural Perkerasan Lentur menggunakan Metode AASHTO 1993 and Metode Bina Marga 2013 Studi Kasus: Jalan Nasional Losari – Cirebon. Jurnal Teknik Sipil, Volume 22, (2015), pp. 147-164.

[3] Badan Standarisasi Nasional, Cara Uji Lendutan Perkerasan Lentur dengan Alat Benkelman Beam SNI 2416-2011, Jakarta, (2011).

[4] Bina Marga, Perencanaan Tebal Lapis Tambahan Perkerasan Lentur dengan Metode Lendutan Pd T-05-2005-B, Jakarta, (2005).

[5] Bina Marga, Desain Perkerasan Jalan Lentur No. 002/P/BM/2011, Jakarta, (2011).

[6] Bina Marga, Manual Desain Perkerasan Jalan No. 02/M/BM/2013, Jakarta, (2013).

[7] Hardiyatmo, H. C., Pemeliharaan Jalan Raya, Edisi ke 2, Yogyakarta: Gadjah Mada University Press, (2015).

[8] Hardwiyono, S., Pengaruh Perubahan Suhu pada Modulus Elastik Lapisan Beraspal Perkerasan Lentur dalam Pengujian Regangan yang Berbeda. Jurnal Ilmiah Semesta Teknika, Volume 14, (2011), pp. 72-80.

[9] Hardwiyono,S., Metode Pelaksanaan Perkerasan Jalan, Yogyakarta: LP3M Universitas Muhamma-diyah Yogyakarta, (2013).

[10] Morisca, W., Evaluasi Beban Kendaraan terhadap Derajat Kerusakan and Umur sisa Jalan (Studi Kasus: PPT. Simpang Nibung and PPT. Merapi Sumatera Selatan). Jurnal Teknik Sipil and Lingkungan, Volume 2, (2014), pp. 692-699.

[11] Sari, D. N., Analisa Beban Kendaraan terhadap Derajat Kerusakan Jalan and Umur Sisa. Jurnal Teknik Sipil and Lingkungan, Volume 2(4), 615-620, (2014).

[12] Setyawan, Ari., Jolis, Nainggolan., Arif, Budiantoro., Predicting the Remaining Service Life of Road Using Pavement Condition Index. Journal Procedia Engineering, Volume 95, (2015), pp. 417-423.

[13] Solanki, Ujjval J., Pradip J. Gundalia., Mansukh D. Barasara., A Review on Structural Evaluation of Flexible Pavements using Falling Weight Deflectometer. Journal of Trends in Transport Engineering and Applications, Volume 2, (2015), pp. 1-10.

[14] Tho'atin, U., Setyawan, A., and Suprapto, M., Penggunaan Metode International Roughness Index (IRI), Surface Distress Index (SDI), and Pavement Condition Index (PCI) untuk Penilaian Kondisi Jalan di Kabupaten Wonogiri. Seminar Nasional Sains and Teknologi, Jakarta, 8 November ,(2016), pp. 10-18.

[15] Wicaksono, A.N., Perencanaan Tebal Lapis Tambah Metode Pd T-05-2005-B and Metode SDPJL pada Jalan Nasional di Yogyakarta. Jurnal Matriks Teknik Sipil, Volume 5, (2017), pp. 623-631.

Rehabilitation Planning for Flexible Pavement using Rebound

ORIGINALITY REPORT

6%	%	6%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Ary Setyawan, Jolis Nainggolan, Arif Budiarto. "Predicting the Remaining Service Life of Road Using Pavement Condition Index", Procedia Engineering, 2015 Publication	2%
2	"Structural evaluation of flexible pavement using Falling Weight Deflectometer", Multi-disciplinary Sustainable Engineering Current and Future Trends, 2016. Publication	1%
3	A Rahmawati, E Adly, I Lutfiyanto, M A Syifa. "The Overloading Effect on the Design Life of Road and Thickness of Pavement Layer", IOP Conference Series: Materials Science and Engineering, 2019 Publication	1%
4	T A Balqis, S Suherman. "The effect of using crumb rubber on fatigue and rutting lives in flexible pavement", IOP Conference Series: Materials Science and Engineering, 2020 Publication	1%

5	Budi Yulianto, Setiono. "Implementation of android-based urban freight transport violation reporting application in Surakarta city", AIP Publishing, 2018 Publication	1%
6	N M Barudin, H Yaacob, N A Hassan, M N M Warid et al. "Correlation between functional and structural properties of flexible pavement", IOP Conference Series: Earth and Environmental Science, 2019 Publication	<1%
7	A. Beerbower. "A Critical Survey of Mathematical Models for Boundary Lubrication", A S L E Transactions, 1971 Publication	<1%
8	Derek Tompkins, Luke Johanneck, Lev Khazanovich. " State Design Procedure for Rigid Pavements Based on the AASHTO ", Transportation Research Record: Journal of the Transportation Research Board, 2019 Publication	<1%
9	S.W. LANIGAN. "Port wine stains on the lower limb: response to pulsed dye laser therapy", Clinical and Experimental Dermatology, 3/1996 Publication	<1%
10	Lawrence M. Iregbulem. "Postburn Volar Digital Contractures in Nigerians", Hand, 2016	<1%

Publication

11	Mishbahul Aziz, Sigit Winarto, Yosef Cahyo S.P. "Studi Analisa Perencanaan Perkerasan Lentur Dan Rencana Anggaran Biaya (Pada Proyek Jalan Ruas Jalan Tambelangan – Durjan Kabupaten Sampang)", Jurnal Manajemen Teknologi & Teknik Sipil, 2019 Publication	<1%
12	"Advancement in the Design and Performance of Sustainable Asphalt Pavements", Springer Science and Business Media LLC, 2018 Publication	<1%
13	Jianlin Wang, Bjorn Birgisson, Reynaldo Roque. "Windows-Based Top-Down Cracking Design Tool for Florida", Transportation Research Record: Journal of the Transportation Research Board, 2007 Publication	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		

International Journal of Integrated Engineering

5

H Index

Country Malaysia - SIR Ranking of Malaysia

Subject Area and Category
Engineering
- Civil and Structural Engineering
- Electrical and Electronic Engineering
- Industrial and Manufacturing Engineering
- Mechanical Engineering
- Mechanics of Materials

Materials Science
- Materials Science (miscellaneous)

Publisher Penerbit UTHM

Publication type Journals

ISSN 2229838X

Coverage 2017-ongoing

Scope The International Journal of Integrated Engineering (IJIE) is a single blind peer reviewed journal which publishes 3 times a year since 2009. The journal is dedicated to various issues focusing on 3 different fields which are:- Civil and Environmental Engineering. Original contributions for civil and environmental engineering related practices will be publishing under this category and as the nucleus of the journal contents. The journal publishes a wide range of research and application papers which describe laboratory and numerical investigations or report on full scale projects. Electrical and Electronic Engineering. It stands as a international medium for the publication of original papers concerned with the electrical and electronic engineering. The journal aims to present to the international community important results of work in this field, whether in the form of research, development, application or design. Mechanical, Materials and Manufacturing Engineering. It is a platform for the publication and dissemination of original work which contributes to the understanding of the main disciplines underpinning the mechanical, materials and manufacturing engineering. Original contributions giving insight into engineering practices related to mechanical, materials and manufacturing engineering form the core of the journal contents.

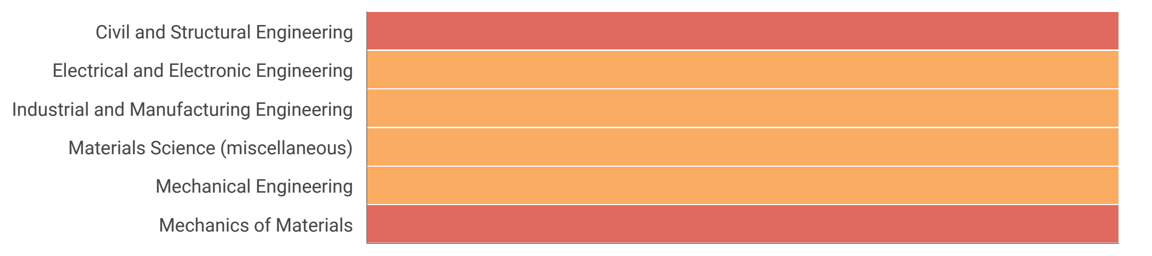
Homepage

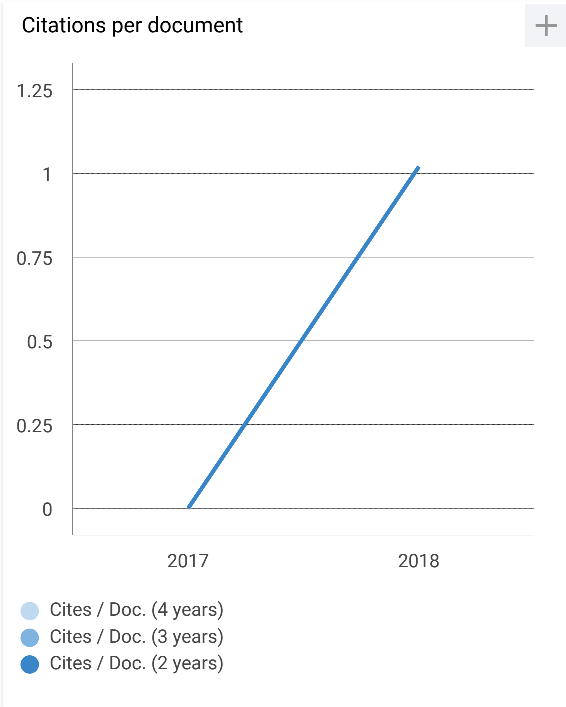
How to publish in this journal

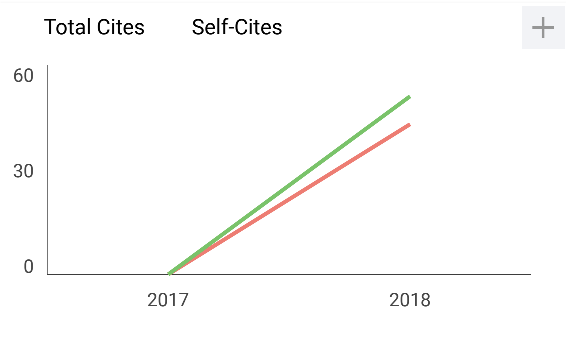
Contact

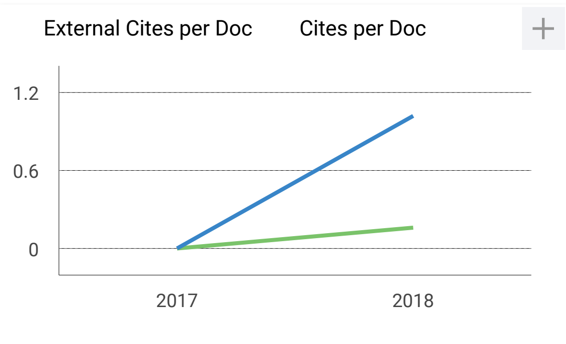
Join the conversation about this journal

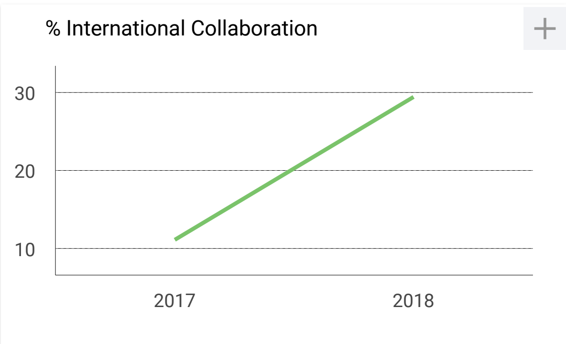
Quartiles

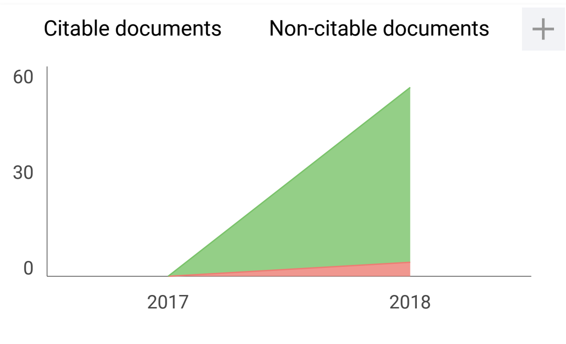


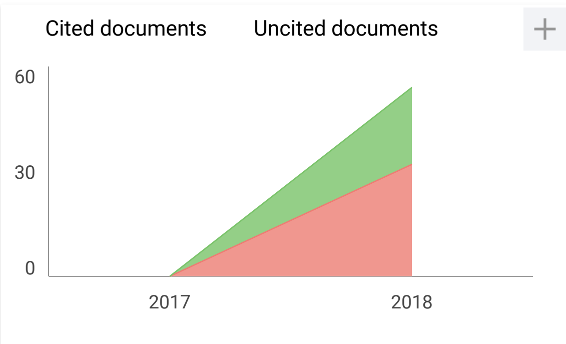












← Show this widget in your own website

Just copy the code below and paste within your html code:

<a href="https://www.scimag

A

Afnan Ahmad 2 months ago

Dear Editor,

I recently submitted a journal artical in this journal. I am here to know about the review period of this journal.

Thanks

reply

SCImago Team

Melanie Ortiz 2 months ago

Dear Afnan,
thank you for contacting us.
Sorry to tell you that SCImago Journal & Country Rank is not a journal. SJR is a portal with scientometric indicators of journals indexed in Elsevier/Scopus.
Unfortunately, we cannot help you with your request, we suggest you to visit the journal's homepage or contact the journal's editorial staff , so they could inform you more deeply.
Best Regards, SCImago Team

J

JAIME LARUMBE 3 months ago

Dears,

I would like to know if you are interested about an article about Systems Engineering/ Configuration Management.

Thanks,

Jaime

reply

SCImago Team

Melanie Ortiz 3 months ago

Dear Jaime,
thank you for contacting us.
Sorry to tell you that SCImago Journal & Country Rank is not a journal. SJR is a portal with scientometric indicators of journals indexed in Elsevier/Scopus.
Unfortunately, we cannot help you with your request, we suggest you to visit the journal's homepage or contact the journal's editorial staff , so they could inform you more deeply.
Best Regards, SCImago Team

M **Misbah Ohag** 8 months ago

Dear Sirs
I want to send a research paper in this journal.
Please advise regarding the fees of publication and is it indexed by Scopus ?
Regards
Misbah
PhD studet - UITM

reply

P **Pushpdant Jain** 2 months ago

There is no article processing fees for this journal

SCImago Team

Melanie Ortiz 2 months ago

Dear user, thanks for your participation! Best Regards, SCImago Team

M **Mohanad Alaasam** 2 years ago

Dear Dr.
Can I publish my paper in your journal in electrical engineering .
Can you inform me abot
1-the prriod of accepted the paper.
2-the cost of publishment .
Thank you

reply

M **Mohanad Alaasam** 2 years ago

Dear Dr.
Can I publish my paper in your journal in electrical engineering .
Can you inform me abot
1-the prriod of accepted the paper.
2-the cost of publishment .
Thank you

reply

M

Mohanad Alaasam 2 years ago

Dear Dr
Can Ipublish my paper in your journal .
So can you inform me the period of accepted the paper and the cost of publishment .
Thankyou

reply

SCImago Team

Elena Corera 2 years ago

Dear Mohanad, in the link below you will find the information corresponding to the author's instructions of this journal. Best regards, SCImago Team

http://penerbit.uthm.edu.my/ojs/index.php/ijie/information/authors

Leave a comment

Name

Email
(will not be published)

I'm not a robot
reCAPTCHA
Privacy - Terms

Submit

The users of Scimago Journal & Country Rank have the possibility to dialogue through comments linked to a specific journal. The purpose is to have a forum in which general doubts about the processes of publication in the journal, experiences and other issues derived from the publication of papers are resolved. For topics on particular articles, maintain the dialogue through the usual channels with your editor.