Pavement Roughness Measurement as an Aid to Assess Maintenance Needs.

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Abstract

A good road structure may help in reducing the number of accidents. The international roughness index and present serviceability rating are indices that can be used as indicator of road roughness and serviceability. This study was carried out from mile one to Oyibo junction, a major road in Rivers State, which measures about 18km.The study was carried out by simple tools of tape and six feet plumb, raters form was also given to six observers who rode through the route and gave their subjective judgment based on their observations. The route was divided into six sections at 3km each, from the data collected and observers' judgment, the route has an average PSR of 2.53, Present Serviceability Index, PSI of 3.18, change in initial and terminal serviceability of 1.32 and change in serviceability of 1.5. The terminal serviceability Index (Pt) is the lowest acceptable level before resurfacing or reconstruction becomes necessary, hence the route needs reconstruction.

Keywords: *Pavement, Roughness, Present Serviciabilty Rating, Present Serviciability Index,IRI*

1.0 Introduction

According to the continuously increasingly rate of economic and developmental activities in several countries including Nigeria, traffic loads is on the increase and causing roads devastation. Allocated funding resources and infrastructure requirements are generally considered inappropriate and not being enough with highly growing maintenance demands, which in turn caused a large deterioration in roads pavement.

Pavement roughness is generally defined as an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle (and thus the user). Roughness is an important pavement characteristic because it does only affect the ride quality but also vehicle delay costs, fuel consumption and maintenance costs. The World Bank found roughness to be a primary factor in the analysis and trade–offs involving road quality versus user cost. Pavement roughness or ride quality is qualified by the serviceability performance concept developed at the AASHTO text in 1957.

In the other hand, road roughness can be defined as an expression of irregularities in the longitudinal profile of pavement surface that adversely affect the riding quality of a vehicle and thus affect the user.

Therefore, it is expected that smoother roads will last longer. Permit me to say that the impact of pavement roughness can help stakeholders under ways & leverage road design and maintenance in order to minimize fuel consumption, tear and wear on our vehicle, reduce vehicle maintenance cost and time delay, but will go a long way to maximize the use of limited road construction and maintenance funding.

Pavement distresses are those defects visible on the pavement surface. They are symptoms, including some problems or phenomenon of pavement deterioration such as cracks, patches and ruts. The type and severity of distress as a pavement can provide great insight into what its future maintenance and/or rehabilitation needs will be. Road Roughness is the most important condition parameter influencing road user comfort and, more importantly, vehicle operating cost (VOC). This study is based on evaluating different pavement distress to bring a functional and lasting maintenance needs for the comfort of the road users. Generally, it has been universally witnessed that both traffic volume and loads on roads are increasing from year to year with alarming rate all over the world. Such heavy traffic growth demands better performance roads for efficient transport of agricultural, commercial and industrial products without delay. Roughness condition has been used as the criteria for accepting new contraction of pavement including overlay and also as the performance measure to qualify the surface performance of existing pavements in a pavement management system at both network level and project level in most of the time.

Pavement undergoes a process of deterioration directly after opening to traffic. This process under the effects of traffic and environmental conditions begins very slowly so that it may not be noticeable. Overtime, the pavement deterioration has different mechanisms and faster rate of deterioration.

Timing of maintenance action is important since it must be carried out at the time of maximum return. Otherwise, the maintenance needs will be higher if the pavement is allowed to experience further deterioration. Pavement maintenance can be categorized into two main categories according to Al-mansour and Kumares (1993) as, corrective and preventive maintenance. The current practices of most highway authorities concentrate on the first category, the minor attention given to preventive maintenance. The main reason for this is the shortage of available funds which directs some decision makers toward putting the limited funds on corrective maintenance to satisfy road users, leaving nothing or, at most a negligible portion for preventive maintenance. However, this strategy is not recommended.

The general objectives of this research work are ;

To use pavement roughness data to know the serviceability state of the pavement at all times. The scope of this research was limited to one major road in Port Harcourt metropolis, Aba road (from mile flyover to oyibo express junction). The roughness of the road has its own significant effect on vehicle operating cost; therefore roughness has its own effect on the vehicle operating cost for a vehicle travelling over a section of road. The rougher the section of road, the higher the operating cost.

2.0 Materials and Methods

2.1 Research Design

The core objective of this research was to use pavement roughness data to assess maintenance needs of the pavement. Port Harcourt Aba-express way (from Mile 1 to Oyigbo express junction) which measures about 18km and serves as one of the major roads in Port Harcourt was selected, due to its traffic demands as it serves a major route to some neighboring states like Abia. The road pavement condition covered the range of possible conditions (good, fair and poor) with different pavement distresses.

Data collection was carried out in the study site "Aba road i.e mile 1 to Oyigbo express junction" in Port Harcourt, Rivers State. The necessary data collected were;

- Roughness index by 6feet plumb and a tape at each section.

User assessment was conducted by distributing raters form. User assessments data were used to estimate the present serviceability index of the road.

2.2 Composition of the Panel

The people that made up the evaluation panel were one of the most important aspects in this study; they had to represent the public generally. The category of observers selected ranges from those with first degree to senior school certificate who could communicate effectively.

1. They needed a broad range of experience both as drivers and passengers in cars, as well as passengers in public transportation buses, and
2. They did not have any kind of bias or prejudice regarding trips in cars and buses.

2.3 Training of the Members of the Evaluation Panel

Training of the evaluation panel and the instructions was very important in the process of subjective rating. Studies have shown that a team rating a subjective variable without receiving any instructions obtains results that are different to another team who has received instruction.

2.4 Nature/Source of Data

The data for this research work were gotten from field measurement and design documents.

2.5 Methods of Data Collection

Data collected for the analysis were obtained from design documents and through field measurements and have shown different characteristics. Roughness, user assessment, and performance indicators measurement.

The types of data gathered during field data collection were;

1. Road roughness data collected at different sections.
2. Rut depth.
3. Distribution of prepared raters form for the experts/ drivers.

2.6 Procedures Used to Measure Roughness

Plum and Tape: This was a manual method of measuring roughness. A long plum of about 6feet and a tape were used to measure the distressed area and the depth was recorded. It was a tedious practice and took a longer time.

2.7 Design of the Rating Form

In this study, the widely used AASHTO scale was adopted. It consists of reporting in words the levels of quality, in addition to a line where the person performing the rating makes a mark. The other evaluation category that was used in the acceptance criteria. In it, the evaluator is asked to judge if the ride quality on the section seems acceptable or not. The responses to this segment of the form provide a measure of the minimum acceptance threshold of functional quality of pavements. It was imperative for the form to be simple, so that it enabled the evaluator

to rapidly judge and decide the serviceability rating as well as his/her position regarding the acceptance or not of that ride quality.

Figure 2.1 shows this form.

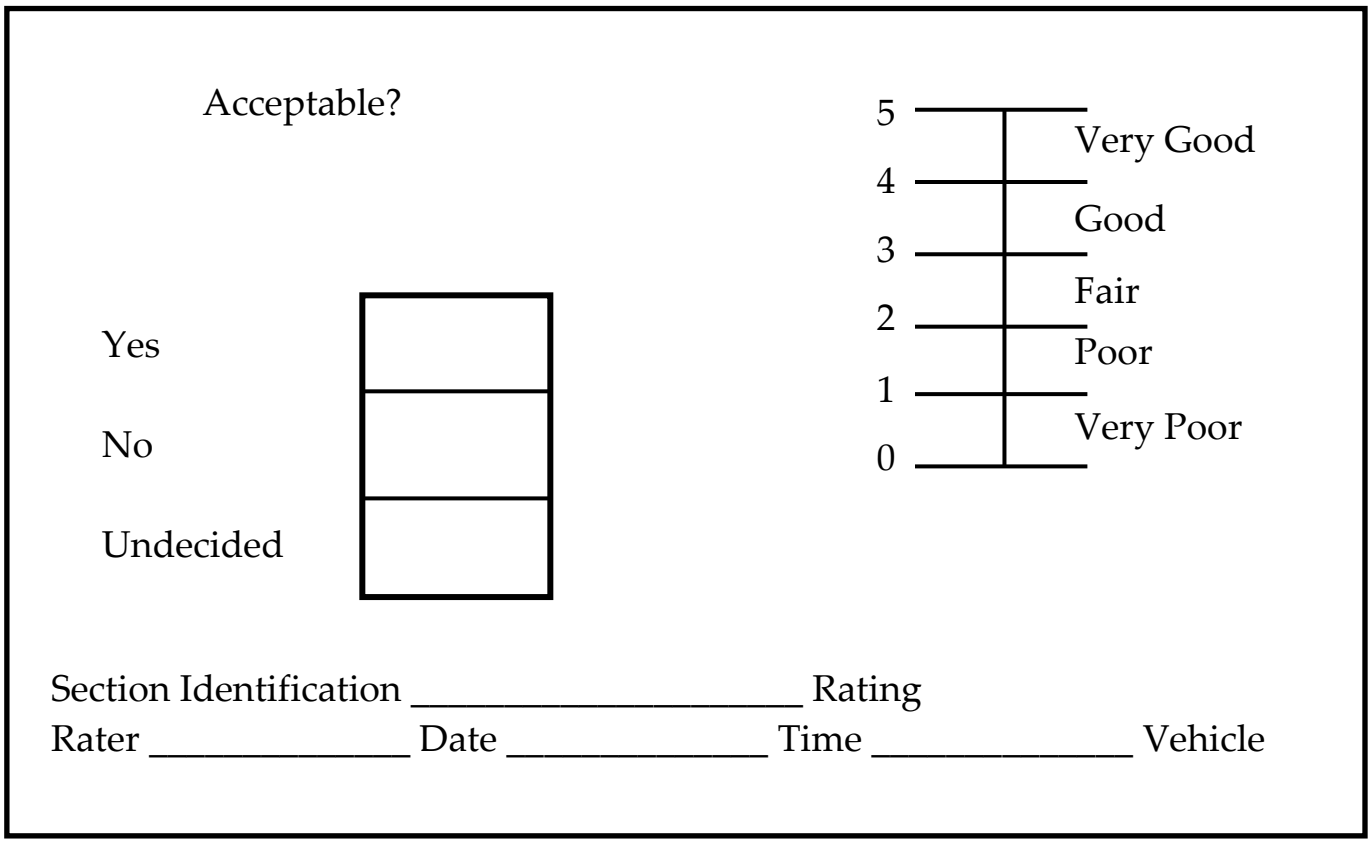

Figure 2.1: sample of the Rating form.

2.8 Determination of Present Serviceability Rating (PSR)

Present Serviceability Rating from very good to very poor as gathered from the field rater or the driven, guide line used for the driven are questionnaire requesting road performance from very good to very poor. The scale for the rating is described as:

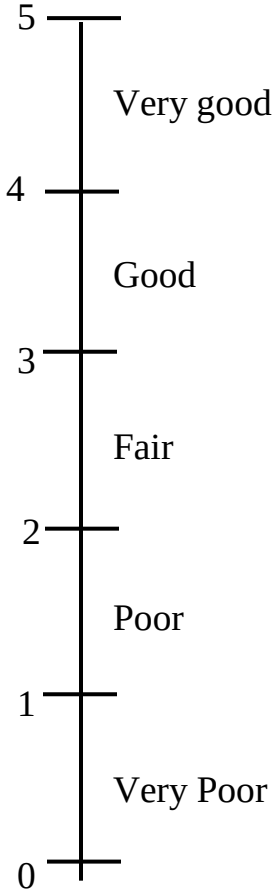

Figure 2.2: Scale for the rating of user assessment.

By distributing questionnaire to the driver on the study site, different rating values had been gathered from the selected section of mile 1- Oyibo Express Junction road segment.

2.9 User Assessment and Analysis

User assessment was the road users feedback to the road pavement, in order to evaluate the performance rating of the pavement, driven who drove around the pavement gave rate for the pavement, in this research for the study route of Mile one- Oyibo Express Junction various section were rated by road users and the value was assign as shown in Table 3.2 from very good to very poor and the assigned values of (4-5) and (0-1) respectively.

Drivers who consistently drove around the study route to give a rating for the pavement with their vehicle are rater who gave present serviceability rating for the road with a distributed questionnaire.

3.0 RESULTS

3.1 Presentation of Data

Roughness data collected from the six sections of the study route at 3km each on both sides of the road are given in table 3.1.

Table 3.1; Measured Depth Values from Field

Section	D – values (mm)	
	Right	Left
1	75	55
2	80	68
3	60	51
4	225	223
5	323	300
6	426	450

The derivation of the Depth (D) values from equation 3.1 was calculated for the six sections of the study route. The International Roughness Index (IRI) can be calculated from the model.

IRI = 0.593 + 0.0471D (2.4>IRI>15.9) 3.1

(Source: Handbook of Highway Engineering)

Where IRI = International Roughness Index.

D = Depth Value Measured on site.

Table 3.2 shows the calculated value of D and IRI for each section of the road.

Table 3.2: Evaluated values of D and IRI

			IRI = 0.593 + 0.0471D		
Section	D – Value		IRI Value		
	Right	Left	Right	Left	IRI average value R +L/2
1	75	55	4.13	3.18	3.66
2	80	68	4.36	3.80	4.08
3	60	51	3.42	3.00	3.21
4	225	223	11.20	11.57	11.39
5	323	300	15.81	14.72	15.27
6	426	450	20.61	21.79	21.20
					Average = 9.8

This is the summarized value for depth D and IRI

3.1.1 Determination of Present Serviceability Rating PSR and Users Assessment

Present Serviceability Rating from very poor to very good as gathered on the field from the raters (drivers) was given in table 3.3

Table 3.3: Evaluation result for all selected section of the user assessment rating.

Section	Very good	Good	Fair	Poor	Very poor
	(4.5)	(3-4)	(2-3)	(1-2)	(0-1)
Section 1		3.9			
Section 2		3.25			

Section 3	3.20				
Section 4		2.8			
Section 5			1.5		
Section 6				0.5	

Performance rating value for the road segment as evaluated from all rater was:

Average PSR = $\frac{(3.9 + 3.25 + 3.20 + 2.8 + 1.5 + 0.5)}{6}$

PSR = 2.53

The International Roughness Index (IRI) value versus user rating evaluation Present Serviceability Rating (PSR) value as tabulated in table 3.4

Table 3.4: Serviceability rating (PSR) value for each of the Six Sections

Section point	Section length (km)	IRI (m/km)	PSR
Section 1	3	3.66	3.9
Section 2	3	4.08	3.25
Section 3	3	3.21	3.20
Section 4	3	11.39	2.8
Section 5	3	15.27	1.5
Section 6	3	21.20	0.5

Prediction of present serviceability index (PSI) with the measured value of roughness index correlation with PSR. In this research, during estimation of PSI, distress data is not used due to its relatively small contribution to PSI and the difficulty in the measuring and obtaining the distress data, only rut was used to determine PSI.

$PSI = X_o + X_1 \log IRI$ 3.1

Where X_o and X_1 are regression coefficients

IRI = International Roughness Index

From table 4.3.2 by using the values of each section of the study site IRI and PSR the linear regressions can be analyzed as shown in tables 4.5 to 4.7

Summary Output

Table 3.5 Output of regression value

Model Summary

R square	0.917
Adjusted R square	0.896
Standard Error	0.410

Table 3.6 Summary of output value of regression

ANOVA					
	Df	Ss	Ms	F	Significant F
Regression	1	7.426	7.426	44.132	0.003
Residual	4	0.673	0.168		
Total	5	8.099			

Table 3.7 Standard Error

Unstandardized coefficient		Standardized Coefficients	t	Significance
B	Standard Error	Beta		
4.132	0.294		14.044	0.000
-0.164	0.025	-0.958	-6.643	0.003

The above Tables from 3.4 to 3.7 explain the correlation between measured performance indicator (roughness) and the user assessment (serviceability rating).
As shown from the regression output the variables X_o and X_1 are determined and the value for PSI. The regression output values are substituted in equation 3.2 to obtain the value of PSI from the model.
From the model, $PSI = X_o + X_1 \log IRI$
$PSI = 4.132 + 0.96\log IRI$, $X_o = 4.132$, $X_1 = -0.96$ 3.3
$PSI = 4.132 – 0.96 \log 9.8$
$= 3.18$

3.2 Data Analysis

The PSI value is the determined value of the road which shows the current performance of the route mile one to Oyibo express function.
The present serviceability index calculated in equation 3.3 was 3.18. And assuming that initial and terminal serviceability indexes according to AASHTO flexible pavement design manual and handbook of highway engineering, the recommended terminal serviceability index value point is 3 for major roads, 2.5 for intermediate road and 2 for secondary roads. And also a well-constructed new pavement has initial serviceability index (PSI_o) 4.2 to 4.5
Therefore change in initial serviceability index is given in equation 4.5 as:
$\Delta PSI = P_o – P_t$ 4.5
In this research, the standard of the mile one – Oyibo study route fall under major road and the terminal serviceability index of 3 was used for the evaluation of change in serviceability thus:
$\Delta PSI = 4.5 – 3.0 = 1.5$
And change in initial and terminal serviceability is given by
$4.5 – 3.18 = 1.32$.

3.3 Discussion of Findings

For a change in initial and terminal serviceability of 1.32, according to AASHTO flexible pavement design manual and handbook of highway engineering, the road needs to be reconstructed. From the users assessment form, section 5 and 6 with PSR value of 1.5 and 0.5 respectively indicates that the sections are performing very poor or it is very difficult to pass through.

4.0 Conclusions.

All pavements have irregularities built into the surface during construction, so even a new pavement that has not be opened to traffic can exhibit roughness. In this research work of pavement roughness as an aid to assess maintenance needs, the following conclusions were reached:

1. The pavement has rut depth of 450mm average depth.

2. The road has average roughness index of 9. 8
3. The results of the measured distress values show the road running with good condition in some sections and bad condition in a section (section 5-6).
4. The user assessment result gathered from the road user based on the raters form of 0-5 value output evaluation, the average present serviceability rating (PSR) value is 2.53 which indicates that the road is performing in fair condition base on subjective judgment of the raters.

4.1 Recommendations

1. It is recommended that more research be conducted in attempt to get more useful data for proper planning of the maintenance needs of the pavement.
3. This study has certain limitation for example, the data for the analysis was taken from only one route, so it is uncertain to generalize for all types of flexible pavement because every road project has its own unique condition.
4. For easy and efficient data collection, Merlin Machine should be used in collecting data, it makes data collection easier and faster.

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