Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 3159-0040
Vol. 1 Issue 3, October - 2014

INFLUENCE OF PAVEMENT DISTRESS ON TRAVEL TIME

A case study of wuse district, Abuja.

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Abstract- In planning and design process for all aspect of road network, traffic flow parameters estimation is crucial as such travel time which is the reciprocal of speed , an indicator or a measure of the condition and maintenance of the road surface was established in the study using moving car observer method. A 1.2km stretch of the road which is Michael opera street of two lane spanning from Herbert Macaulay way to olusegun obasanjo way wuse zone 2 was used as test section. Before the rehabilitation of the road, a visual assessment of the road was carried out and it was observed that cracks dominated in the pavement distress with about 62% followed by potholes and patches about 20%. The travel time was 3.06mins from A to B and from B to A it was 3.47mins having a flow of 713veh/hr and 700veh/hr with LOS B .However after rehabilitation the travel time reduced to 1.49mins and 1.56mins respectively and a flow of 1177veh/hr and 1014veh/hr was recorded respectively with LOS of C.This paper concludes that there was 51.3% and 55.04% reduction in travel time on both ways and the transportation policy of banning the mini buses from entering the wuse district made them move to this arterial to drop passengers a via berger junction and also the newly rehabilitated road attracted more traffic and we observed an increase in the motorization level after 8months of data collection ,hence adverse condition ,pavement distress reduces travel time.

Keywords - *moving car observer, travel time, level of service, pavement distress.*

I. INTRODUCTION

The influence of pavement surface conditions on travel time has been under-reported and obviously drivers may choose to drive more slowly over a surface that has deteriorated than they would driver over a more even surface. However, it has been postulated that with modern vehicles the effects are reduced and vehicle speeds are maintained but with higher operating costs.

Based on study carried out by Cooper, Jordan, & Young, in 1980, they gathered vehicle speed data for three sites in England due to be resurfaced. At two of the three sites the surface unevenness showed little change before and after resurfacing. At the third site a statistically significantly increase in the traffic mean speed levels was seen following reconstruction of the road. The observed increases in the mean speed after resurfacing were 2 km/h for private cars, 2.3 km/h for light goods vehicles, 2 km/h for medium goods vehicles, and 2.6 km/h for heavy goods vehicles.

Also in Sweden a study was carried out by (Linderoth, 1981) and (Wretling, 1996) to investigated the relationship between road surface condition and travel speed using a sample of resurfaced roads and a control group. They concluded that there was no evidence of reduced speed due to roughness.

(Wretling, 1996) described another Swedish study by (Anund, 1992) that investigated the relationship between surface quality (measured in IRI) and vehicle speed. The results showed that there was a statistically significant speed reduction of 1.6 km/h for passenger cars between 3.00 p.m. and 9.00 a.m. if the rut depth increased by 10 mm, and a reduction of 2.2 km/h for an increase of 1 IRI. The corresponding values during 9.00 a.m. and 3.00 p.m. were 1.9 km/h and 3.0 km/h. For trucks with and without trailers, no significant speed reduction with increased roughness or rut depth was found. The results of those studies support a significant reduction in vehicle speed only when road condition deteriorates beyond some critical level that is rougher than the general level of condition of the trunk road network in Scotland.

Also in 2010 J.Ben-Edigbe carried the assessment of speed-flow-density functions under adverse pavement condition and postulated the relationship between speed, flow under adverse road surface condition. The study was carried out in Nigeria where adverse road surface condition on principal roads is prevalent under day light, dry weather and off-peak conditions. It is based on the hypothesis that adverse road surface condition has significant impact on otherwise uninterrupted traffic stream. The paper compared empirical survey data from11 locations on roadway segments with control and adverse sections. Optimum speeds for control and adverse road sections were estimated and compared. The study found 50% reduction in optimum speed and concluded that significant speed reduction will occur under adverse road surface condition.

II. ROAD PAVEMENT DISTRESS

Road deterioration can be construed as a function of original design, material types, and construction quality, road geometry, pavement age, environmental conditions, maintenance policy pursed, traffic volume and axle loading. Defects are usually manifested in the form of cracking, rutting, raveling, potholes, roughness, edge break, surface texture and polished surface. It can be argued that research into the influence of pavement distress on travel time has not been undertaken before this study, as there are no evidences of literature on previous work. Probably the closest research works are on capacity loss, the road humps and speed cushions. They are usually in the form of measuring road service quality before and after installation of humps or speed cushions with attention concentrated on the level of service and road safety. It can be mentioned in passing that literature on the influence of severe pavement distress on travel time are scarce if at all. This may not be unconnected with the fact that severe pavement distress is mainly found in developing countries where research works are limited for whatever reasons.

A. CASE STUDY DESCRIPTION

The study area from the beginning to the end of Michael opera street adjoining at Herbert Macaulay way and obasanjo way in wuse district of Abuja

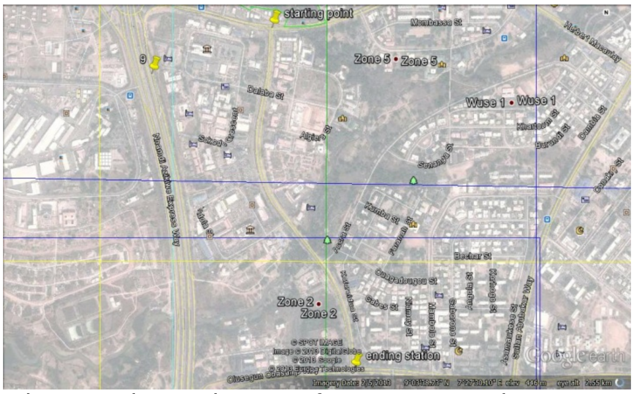


Figure 1.The study area of wuse zone 2 along Michael opara street

III. METHODOLOGY

Determination of any of the two parameters of the traffic flow will provide the third one by the equation.

$$q = u.k$$

Moving observer method is the most commonly used method to get the relationship between the fundamental stream characteristics. In this method, the observer moves in the traffic stream unlike all other previous methods. The method developed by Wardrop and Charlesworth is based on a survey vehicle that travels in both directions on the road.The formulae allow one to estimate both speeds and flows for
one direction of travel. The two formulae are

$$q_{B\text{-}A} = \frac{(Ns+nN)}{(Ts+Tn)}$$

$$\bar{T}_N = T_N - \frac{(nN)}{q\,B-A}$$

where,

$q_{B\text{-}A}$ is the estimated flow on the road in the direction of interest,

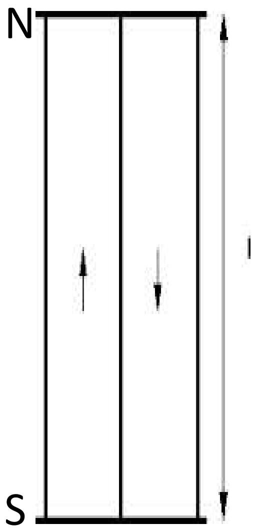
Ns is the number of vehicles traveling in the direction of interest, which are met by the survey vehicle while traveling in the opposite direction,

nN is the net number of vehicles that overtake the survey vehicle while traveling in the direction of interest (i.e. those passing minus those overtaken),

T_N is the travel time taken for the trip against the a stream,

$\bar{T}_N$ is the travel time for the trip with the stream, and is the estimate of mean travel time in the direction of interest. Illustration of moving observer method is shown below

DIRECTION B-A	TRAVEL TIME (MINS)	TRAVELLING IN OPPOSITE DIRECTION	OVER TAKING TEST CAR	OVER TAKING BY TEST CAR.
1	3.3	78	3	0
2	3.35	82	0	2
3	3.5	79	2	2
4	3.4	74	4	3
5	3.7	76	3	1
6	3.9	81	1	1



B. Data collection

Visual assessment of the road pavement was collected on the 17th of December to 20th December 2012 during good weather. The traffic data was collected in august 6th 2012 the time selected was off peak hour from 12noon to 1.00pm when the road was in bad condition and on the 25th of March 2013 another traffic data was collected when the road has been rehabilitated and opened for traffic.

Table 1: vehicle stream data

DIRECTION B-A	TRAVEL TIME (MINS)	TRAVELLING IN OPPOSITE DIRECTION	OVER TAKING TEST CAR	OVER TAKING BY TEST CAR.
1	1.7	50	5	4
2	1.53	48	2	4
3	1.57	52	4	5
4	1.01	53	0	1
5	1.17	45	0	4
6	1.4	49	0	3

DIRECTION B-A	TRAVEL TIME (MINS)	TRAVELLING IN OPPOSITE DIRECTION	OVER TAKING TEST CAR	OVER TAKING BY TEST CAR.
1	3.3	70	2	1
2	3.2	80	0	2
3	2.8	74	3	1
4	2.9	85	2	0
5	3.245	78	0	1
6	3.05	72	1	2

Table 2: vehicle stream data

DIRECTION B-A	TRAVEL TIME (MINS)	TRAVELLING IN OPPOSITE DIRECTION	OVER TAKING TEST CAR	OVER TAKING BY TEST CAR.
1	1.33	52	0	0
2	1.6	71	0	5
3	1.28	67	0	2
4	1.5	54	1	2
5	1.4	49	0	4
6	1.38	47	0	2

DIRECTION B-A	TRAVEL TIME (MINS)	TRAVELLING IN OPPOSITE DIRECTION	OVER TAKING TEST CAR	OVER TAKING BY TEST CAR.
1	3.3	78	3	0
2	3.35	82	0	2
3	3.5	79	2	2
4	3.4	74	4	3
5	3.7	76	3	1
6	3.9	81	1	1
Average	3.53	78.33	2.17	1.5

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IV. RESULTS AND ANALYSIS.

DIRECTION B-A	TRAVEL TIME (MINS)	TRAVELLING IN OPPOSITE DIRECTION	OVERTAKING TEST CAR	OVERTAKING BY TEST CAR.
1	3.3	70	2	1
2	3.2	80	0	2
3	2.8	74	3	1
4	2.9	85	2	0
5	3.245	78	0	1
6	3.05	72	1	2
Average	3.08	76.5	1.33	1.17

Before rehabilitation Stream flow.

Flow BA = $q_{B-A} = \frac{(Ns+nN)}{(Ts+Tn)}$ =

$q_{B-A} = \frac{\{78.33+(1.33-1.17)\}}{(3.53+3.08)}$ = 11.87veh/min.

DIRECTION B-A	TRAVEL TIME (MINS)	TRAVELLING IN OPPOSITE DIRECTION	OVERTAKING TEST CAR	OVERTAKING BY TEST CAR.
1	3.3	70	2	1
2	3.2	80	0	2
3	2.8	74	3	1
4	2.9	85	2	0
5	3.245	78	0	1
6	3.05	72	1	2

Average travel Time $= \bar{T}_N = T_N - \frac{(nN)}{q\,B-A}$

Average travel Time=3.08-$\frac{(1.38-1.17)}{11.87}$

=3.06mins

$q_{B-A} = \frac{\{76.50+(2.17-1.5)\}}{(3.08+3.53)}$=11.67veh/min.

Average travel Time =3.53 - $\frac{(2.17-1.5)}{11.67}$ = 3.47mins

Table 7- After rehabilitation of the road.

$q_{A-B} = \frac{\{57+(1.83-3.5)\}}{(1.40+1.42)}$= 19.62veh/min.

Average travel Time =1.40-$\frac{(1.83-3.5)}{19.62}$=1.49mins

DIRECTION B-A	TRAVEL TIME (MINS)	TRAVELLING IN OPPOSITE DIRECTION	OVERTAKING TEST CAR	OVERTAKING BY TEST CAR.
1	1.7	50	5	4
2	1.53	48	2	4
3	1.57	52	4	5
4	1.01	53	0	1
5	1.17	45	0	4
6	1.4	49	0	3
Average	1.4	50	1.83	3.5

$q_{B-A} = \frac{\{50+(0.17-2.5)\}}{(1.42+1.40)}$=16.90veh/min.

Average travel Time =1.42 -$\frac{(0.17-2.5)}{16.90}$=1.56mins

The existing road before rehabilitation

Newly rehabilitated road

V. DISCUSSION

The flow after rehabilitation is higher as compared to the flow before rehabilitation may be due to banning of mini buses from entering wuse district so they are forced to use this route via berger junction and this is actually not expected since it is in contrast to the fundamental theoretical background of traffic stream that stipulates that during stable flow ,low traffic flow will produce higher traffic speed and high traffic flow produce lower traffic speed which is also seen in the travel time estimated before rehabilitation on both direction 3.06mins and 3.47mins respectively and after rehabilitation 1.49mins and 1.56mins on both direction. There was 51.31% and 55.04% reduction in the travel time from before rehabilitation on both directions which will also reduce operating cost for road users. However using the traffic volume before rehabilitation from A-B and B-A respectively which is 713veh/hr and 700veh/hr Both ways have traffic volume less than 85% of category B road capacity which is 816veh/hr.thus the road was operating in LOS B before the rehabilitation. And after the rehabilitation the traffic volume from A-B and B-A respectively which is 1177veh/hr and 1014veh/hr Also there was a sharp increase in the flow of about 30% to 40% after rehabilitation of the road.

Both ways have traffic volume less than 85% of category C road capacity which is 1224veh/hr.thus the road is now operating in LOS C after rehabilitation. in general one must have expected that the LOS should have improved from B to A at least but it was a contrast from the result may be as a result of the mini buses been given some selected route in wuse district to move, the newly rehabilitated road attracted more traffic or there is increase in motorization level in Abuja with the last eight months

VI. CONCLUSION

• Adverse conditions have significant impact on level of road service however in this study the reverse was the case due to factors ranging from the current transport policy and obvious increase in the motorization level in abuja;
• Significant reduction in travel time by more than 50% would result from adverse road surface condition;
• Significant reduction in traffic flow by up to 30% to 40% would result from adverse road surface condition. it would useful to conduct large scale studies on the extent of travel time reduction due to pavement condition for three lanes and multi-lane highway

Table 9- Capacity for level of service evaluation

LOS	A	B	C	D	E	F
CAPACITY	600	960	1440	1824	2200	>2200

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ACKNOWLEDGMENT

The authors appreciate the efforts of the road research department for the collection of data, their support for this study and the Nigeria Building and Road Research institute for funding this study.