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AN APPRAISAL OF VEHICULAR DELAY COST OF CONGESTED ROAD NETWORKS IN OSOGBO TOWNSHIP

Afolayan, A[1*], Popoola, O. C[2], Gambo, M. D[2], Odeyemi, F. G[3] and Adebayo, T. G[1]

[1]*Department of Civil Engineering Technology, School of Engineering Technology Federal Polytechnic Ede, Osun State, Nigeria.*
[2]*Department of Building Technology, Federal Polytechnic Ede, Osun State, Nigeria*
[3]*Department of Surveying and Geo-Informatics, Federal Polytechnic Ede, Osun State, Nigeria*
*Corresponding author:
E-mail: afolayan.abayomi@federalpolyede.edu.ng; Phone: +234 (0) 7036408408,

Abstract: Every traveler intends to reach their destination safely under the very possible shortest route with the least inconvenience. This study aims at evaluating the delay cost along two selected routes namely Agunbelewo to Oke-Fia as (RA) and Station road to Oja Oba as (RB) in Osogbo. Travel speed and Average Daily Traffic (ADT) were measured using a cine camera; while fuel consumption was measured per litre using the vehicle's fuel gauge. The annual person-hours of delay (APHD) of 824.57hrs and 348.4hrs were obtained for Agunbelewo to Oke-Fia and Station road to Oja Oba respectively. The daily wasted fuel cost for the car on RA and RB are N930/day and N792/day, respectively, while N9, 197.9/day and N7,785/day, was obtained for total delay cost (TDC) for the car on RA and RB respectively. Also, fuel wasted associated with congestion for RA, and RB is 339,778.5 and 288,970.5 naira per year, respectively. The study area's traffic congestion problem can be solved by providing effective public transportation, an efficient off-street parking system, and enforcing traffic rules and regulations.

Keywords: Congestion, Delay, Cost, Destination, Vehicle.

1.0 INTRODUCTION

Traffic congestion refers to the incremental costs resulting from interference among road users (Victoria Transport Policy Institute, 2005). It is travel time or delays above that normally incurred under light or free-flow travel conditions (Lomax, *et al.*, 1997). Congestion is a major transportation problem affecting urban areas; it arises when a roadway system approaches vehicle capacity, resulting in numerous negative impacts ranging from increased fuel consumption, increased travel time, energy loss, and environmental pollution among others. It also reduces mobility, increases driver stress and vehicle maintenance costs. The emission of greenhouse gases (GHG) and excessive consumption of energy resources is a global problem, due its causes and consequences (The United States Environmental Protection Agency, 2013).

Ajala (2011) examined the challenge of traffic management in Osogbo the Osun State capital and discovered the need for transportation planning within the state. Traffic challenges in Akure, Ondo State, Nigeria was also examined by Ogunbodede (2007) using geographic information system (GIS). In the study, traffic information and traffic congestion queries were provided. Okagbue *et al*. (2015) observed that congestion in Lagos State, Nigeria is partly as a result of road user attitudes of disobedience and impatience.

Travel time is the single most important factor that drivers consider when evaluating the utility of alternative routes. However, despite the demonstrated wide range of travel time as a measure of performance, accurate travel times are often difficult and/or costly to obtain, especially when such travel time data are known to vary significantly as a function of trip departure time (Arasan, 2012). Oyedepo and Afolayan (2016) determined vehicular delay cost of congested road networks in Akure, Ondo State, Nigeria, and concluded that provision of adequate transportation systems and enforcement of traffic regulations is the panacea to congestion. In their study, cost and delay was used for the evaluation congestion for minor routes within the studied area. This study evaluates the car delay cost on the congested road networks in Osogbo, Osun State, Nigeria for three major routes within the state capital. This will help in transportation planning and policymaking to ensure effective management of the road network in the study area.

2.0 METHODOLOGY

2.1 The Study Area

Osogbo is the capital city of Osun State with a population of 156,694 according to the 2006 census, is one of the fastest-growing urban settlements in the South Western region of Nigeria. It is located on latitude 7°46"N and longitude 4°34''E, with an area of 47sqkm (National Transport Policy for Nigeria, 2003).

The natural pattern of development is linear along its main roads is Agunbelewo to Oke-fia referred to as Route A (RA). This road connects other street roads such as Oke-fia, GRA, Ring road, and Route B (RB) start from Station Road to Oja oba. **Fig. 1** shows the road network of Osogbo Osun State Nigeria.

2.2 Field Survey

Traffic count was conducted at the selected routes namely: Agunbelewo-Okefia road (RA) and Station-Oja Oba road (RB), to determine the traffic volume. Traffic parameters like speed, density, delay were obtained for both the peak and off-peak period with the help of cine cameral placed at an elevated position. Analysis of the data was carried out to determine daily passage daily cost, annual fuel wastage, and the total delay cost.

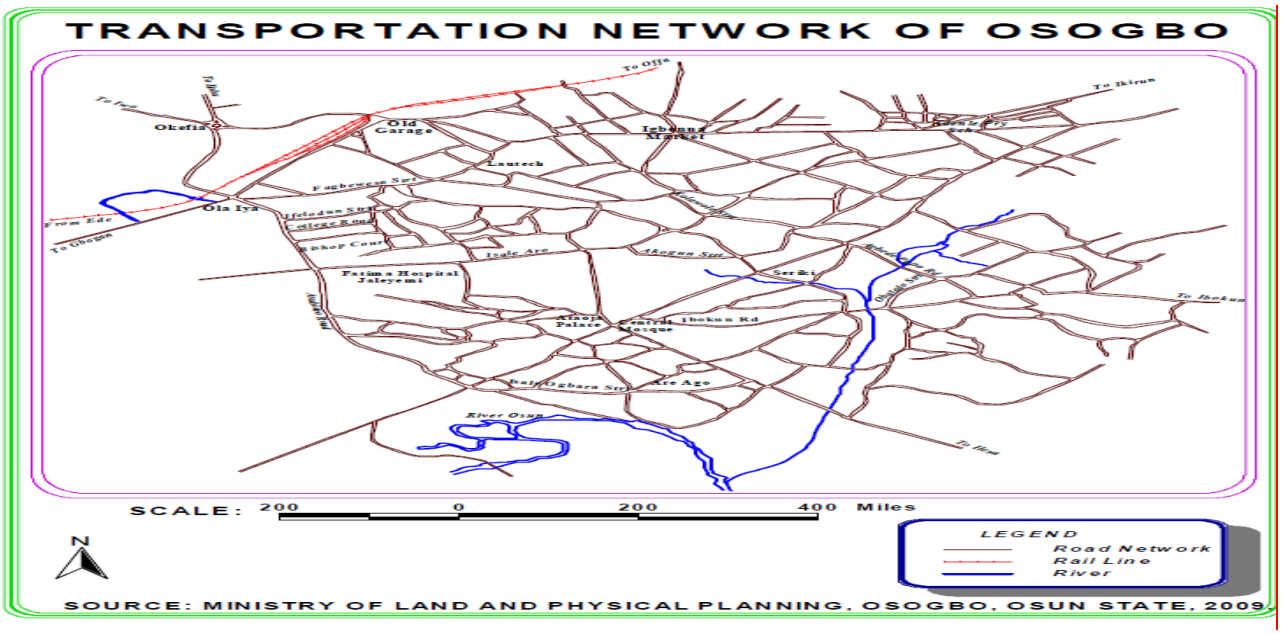

Figure 1: Osogbo Road Network Map

3.0 Results and Discussion

Summary of traffic data obtained for routes A and B are presented in **Table 1**. The vehicle hour of delay, fuel wastage, and congestion cost are contained in **Table 2.**

Route A (RA)

Table 1: Traffic Data for Route A & B

Vehicle Type	Speed at Free flow Condition (km/hr)		Congested Speed (km/hr)		VKT (km/hr)	
	A	B	A	B	A	B
Cars	38	33	18	17	1432	1245

The parameter estimation procedure for route A is presented below:
Length of the road for route A (RA): 12.6km, B (RB) = 15.6km
Free flow time: RA- 20mins = 0.33hr, RB- 28mins = 0.47hr
Congestion Distance: RA = 9.5km, RB = 11.6km
Congestion time: RA-31mins = 0.52hr, RB-40mins = 0.67hr

$$Free\ Flow\ Speed = \frac{distance}{time} = \frac{12.6}{0.33} = 38km/hr$$
$$Congested\ Speed = \frac{congested\ distance}{time} = \frac{9.5}{0.52} = 18km/hr$$
$$Traffic\ Density = \frac{umber\ of\ vehicle}{Length\ of\ road} = \frac{783}{9.5} = 82.42\ Vehicle/km$$
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Note: Vehicle Kilometer of Travel (VKT): Was gotten from the vehicle Speedometer

Delay Cost Estimation

$$PeakPeriodVKT = Daily\ VKT \times X \qquad (Eq\ 1)$$

VKT is the Arterial Street Vehicle Kilometer of Travel = Average Daily Traffic, X is a fraction of VKT taken as 0.45

$$VKT\ for\ Car = \frac{1432}{12} \times 0.45 = 54$$

$$VHD = \frac{(VKT)c}{(TS)c} - \frac{(VKT)c}{(TS)f} \qquad (Eq\ 2)$$

VHD is the Vehicular Hour of Delay, (VKT)c is the Congested VKT, (TS)c is the Congested Travel Speed, (TF)s is the Free Flow Travel Speed

$$VHD\ for\ Car = \frac{54}{18} - \frac{54}{38} = 1.58hr$$
$$APHD\ for\ Car = (VHD)d \times Nv \times Nw \qquad (Eq\ 3)$$

APHD is the Annual Person Hour of Delay, VHD is the Daily Vehicle Hour of Delay, Nv is the No of Person per Vehicle, Nw is the No of Working Days per Year

$$APHD\ for\ Car = 1.58 \times 1 \times 260 = 410.8hrs$$

The proportion of Car is 49.82% Oyedepo, (2014)

$$APHD\ for\ RA = \frac{410.8 \times 100}{48.82} = 824.57hrs$$

Wasted fuel is found based on the change fuel economy and is expressed as follow:

$$(FW)d = \frac{VHD}{FE} \times APPS \qquad (Eq\ 4)$$

(FW)d is the Daily Wasted Fuel, FE is the Average Fuel Economy, APPS is the Average Peak Period System Speed

$$(FW)d = \frac{1.58}{10} \times 20.3 = 3.2lit/day$$

Cost of operating commercial vehicles in the congested condition is calculated as follow:

$$(DPDC)d = Hd \times Pv \times Vx \qquad (Eq\ 5)$$
$$(VDC)d = (VHD)d \times APPS \times Vy \qquad (Eq\ 6)$$

(DPDC)d is the Daily Passenger Vehicle Delay Cost, Hd is the Passenger Vehicle Hours of Delay, Pv is the Values of Person in naira per hour says #450, Vx is the Vehicle Occupancy in Person/Vehicle, (VDC)d is the Vehicle Delay Cost
VHD is the Daily Vehicle-Hours of Delay in an hour, APPS is the Average Peak Period System Speed, Vy is the Vehicle Operating Cost

$$(DPDC)d\ for\ Car = 1.58 \times 450 \times 1 = \#711/day$$
$$(VDC)d\ for\ Car = \frac{1.58 \times 20.3 \times 1100}{12} = \#2{,}940/hr$$

Fuel cost was calculated by assessing the peak period speed, average fuel economy with the vehicle hours of delay

$$(FW)c = (FW)d \times Fc \qquad (Eq\ 7)$$

(FW)c is the Daily Fuel Cost, Fc is the Cost of Fuel per Litre, NOTE: cost of fuel in the studying area #145 per liter

(FW)d is the Daily Wasted Fuel in Litre

$$(FW)c\ for\ Car = 3.2 \times \#145 = \#464/day$$

Daily wasted fuel for vehicle on RA $= \frac{464 \times 100}{49.82} = \#931.4$

Total Delay Cost (TDC) = DPDC + DVDC + (FW)c

TDC is the Total Delay Cost, DPDC is the Daily Passenger Vehicle Delay Cost, VDC is the Vehicle Delay Cost, (FW)c is the Daily Fuel Cost

$$TDC\ for\ RA = \#711 + \#2940 + \#931.4 = \#4{,}582.4$$

Total delay cost TDC for RA $= \frac{4582.4 \times 100}{49.82} = \#9{,}197.$

APHD of 824.5hrs and 348.4hrs were obtained for routes A and B respectively. This implies a huge man-hour loss in delay along the study area. Total annual fuel wastage to congestion on RA and RB is #339,778.5K and #288,970.5K per year respectively. The high amount lost due to congestion is an economic loss to the individual and the country in general.

Table 1: Summary of Vehicle Hour of Delay, Fuel Wastage, and Congested Cost for the Study Area

VHD (hr) Route		APHD (hr) Route		Daily Fuel Wastage (ltr) Route		Annual Fuel Wastage		DPDC (#) Route		DVDC (#) Route		TDC (#) Route	
A	B	A	B	A	B	A	B	A	B	A	B	A	B
1.58	1.34	824.5	348.4	6.42	5.46	2343	2059	711	603	2,940	2,484	9,197	7,785

VHD = vehicular hour of delay, APHD = annual person hour of delay, DPDC = daily passenger vehicle delay cost, DVDC = daily vehicle delay cost, TDC = total delay cost.

4.0 CONCLUSION

According to the study conducted on RA and RB, traffic congestion occurs on the route in question owing to factors such as insufficient road width, inefficient capacity, on-street trading, and ineffective law enforcement, as well as poor road maintenance. The high cost of congestion in the investigated route is attributed to a lack of coordination between transportation and land use planning, sitting market adjacent to the road, taxi drivers' loading and unloading habits near the intersection, and, most crucially, foot traffic are conditions that are prevailing in the study area.

5.0 RECOMMENDATIONS

(1) Providing good public transportation, and efficiently managing off-street parking, and enforcing traffic laws are all examples of strategies that can be employed in the study area and other similar routes.

(2) Markets situated closed to the roads should be moved to other locations.

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