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EFFECT OF HEAVY VEHICLE TRAFFIC ON BENIN – AUCHI ROAD, EKPOMA AXIS

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ABSTRACT
The continuous deterioration of pavement in Ekpoma has been adduced largely to the rapid increase in heavy vehicles carrying much in excess of permitted legal limits. The present study investigated levels of deterioration caused by heavy vehicles through 14days' traffic counts conducted at 5 strategic points each in the city. Traffic data generated from vehicle count were analyzed with AASTHO Designs Guidelines (1993) to evaluate Equivalent Single Axle Loads (ESALs) and vehicle damage effects on the road. The Traffic Volume, Average Daily Traffic (ADT) and Heavy Vehicle per day (HV/day) were 694,023, 49,573 and 19,239 respectively. Motorcycles, passenger cars, mini buses/pick – ups and heavy vehicles constitute about 6.3% (44,059), 37.9% (262,743), 19.9% (117,878) and 38.8% (269,343) of the total traffic volume respectively. An average Load Equivalency Factor (LEFs) was estimated for the heavy vehicles plying the road to be 3.06 and this could explain some failures (alligator cracks, potholes, depressions, linear or longitudinal cracks along the center line amongst others) inherent on the road. Installation and operation of weigh bridges in strategic locations are essential to monitoring and regulating the axle loads of heavy vehicles using Nigerian roads, ensuring that they do not exceed the maximum allowable load limit prescribed in pavement design specifications.
Keywords: *Heavy vehicles, Traffic counts, Equivalent Single Axle Load, Load Equivalency Factor.*

1.0 INTRODUCTION

A road pavement is defined as a layered structure that is supported by the subgrade soil to form a carriageway of a road. It is a type of hard surface that is made from durable surface materials that are laid down to carry heavy load of vehicular traffic (Civil Jungle, 2022) Traffic loading is one of the major determined factors to the deterioration and failure of pavement systems. It follows that traffic loading is one of the important input parameters in pavement design methods (MRS Mshali, 2022). Heavy vehicle loads on the pavement subjects them to high stresses causing damage. However, not all vehicles have the same damaging effects, as damage on the road pavement depends on speed, wheel loads, numbers and location of axles, load distributions, types of suspension, number of wheels, tire types, inflation, pressure and other factors (Savio *et, al*., 2016; Rachael *et, al*., 2018).

The deterioration of pavement is largely attributed repetitive stresses, strain and deflections caused by traffic loads, ultimately reaching a condition that necessitates strengthening (Osadebe and Quadri, 2021). The work examined the damaging effects of heavy axles on flexible pavement on Ekpoma roads. The frequent movement of heavy vehicles on Ekpoma roads has led to various forms of pavement failure, including potholes, cracks, rutting, and surface deformation. These conditions have reduced road quality, shortened road lifespan, and increased maintenance costs. Poor road conditions have also resulted in traffic congestion, longer travel times, and higher vehicle operating costs for road users. Therefore, the problem addressed in this study is the increasing deterioration of

Ekpoma roads due to heavy vehicle traffic and the resulting challenges to road safety, mobility, and sustainable transportation development within the town. The town has experienced rapid urban development in recent decades, evidenced by the expansion of road networks, educational institutions, healthcare facilities, commercial centers, and residential settlements. Ekpoma has a population estimated to exceed 290,000 inhabitants as at 2020 and covers a land area of approximately 502km². Ekpoma is located in the humid tropics. It has the humid tropical climate characterized by wet and dry seasons. (Dr. Ilenre, et al, 2025). Ekpoma Road carries a high volume of mixed traffic, including passenger cars, buses, motorcycles, and a substantial proportion of heavy commercial vehicles transporting goods across the southern and northern regions of Nigeria (UN – Habitat, 2024). The increasing volume of heavy vehicles on this road makes it suitable for assessing the impact of heavy traffic loading on pavement performance.

A preliminary field investigation was conducted along Ekpoma Road to assess the general pavement condition and identify visible signs of deterioration. The investigation involved visual inspection of the carriageway, shoulders, drainage facilities, and embankments to determine the extent and nature of pavement distress such as cracking, potholes, depressions, rutting, and edge failures. The reconnaissance survey also aided in identifying suitable locations for traffic data collection. Based on accessibility, traffic flow characteristics, and pavement condition, five strategic locations were selected along Ekpoma Road for traffic counts. These locations were: Iruekpen Junction, Abia Junction, Ujoelen (G2) Junction, Ukpenu (Mosco) Junction and Opoji Junction

2.0 TRAFFIC DATA COLLECTION AND ANALYSIS

a) Data Collection

Traffic data were collected through a fourteen – day manual traffic count survey conducted at the selected locations along Ekpoma Road between Monday, 3rd and Sunday, 16th March 2025. Manual counts were carried out using hard – tally sheets to record visually observed vehicles. The survey was conducted continuously during the study period, excluding days immediately preceding or following major public holidays, festive periods, market days, political events or major road construction activities to avoid abnormal traffic conditions as prescribed by the Texas Department of Transportation (TxDOT), 2025 regulation. The traffic survey was conducted continuously for fourteen (14) consecutive days from 6:00am to 8:00pm daily resulting in a fourteen – hour observation period each day. The selected time range covered the morning peak period, midday traffic flow, evening peak period and the off – peak movements, thereby capturing the majority of vehicular activities occurring along the study corridor. The choice of 6:00am as the commencement time was based on preliminary reconnaissance surveys which indicated that commercial institutional and commuter traffic activities began increasing significantly from early morning hours. Similarly, the closing time of 8:00pm was adopted because traffic volume reduced considerably after this period and night – time manual counting posed safety and visibility challenges for the field enumerator. Similar traffic count durations have been adopted in previous studies where night traffic was relatively low and or where security concerns limited overnight operations (Kusimo & Okafor, 2014)

Traffic counts were recorded at one – hour intervals and categorized by direction of flow (Benin – bound and Auchi – bound). At each location, two enumerators were stationed simultaneously – one assigned to each traffic direction – to ensure accuracy and completeness of the data collected in line with standard traffic engineering procedures for classified traffic counts and pavement traffic studies (TRL, 2004). Vehicles were classified into Motorcycles; Passenger cars; Mini buses and pick – ups and Heavy vehicles (trucks and trailers) (TRL, 2004). Due to the absence of functional weighbridge facilities along the road corridor, direct axle load measurements were not conducted. However, standard axle load assumptions based on recognized pavement design guidelines such as the Federal Highway Administration (FHWA), 2025, were adopted for analysis.

b) Data Analysis

In evaluating pavement damage, particular attention was given to heavy vehicles due to their significant contribution to pavement deterioration. Heavy vehicles were classified in accordance with the 1993 AASHTO Design Guide into truck classes known to impose substantial structural damage on flexible pavements. The heavy vehicle classes considered included: Class 6B: Two – axle trucks and trailers, Class 7A: Three – axle trucks and Class 7C: Multi – axle trucks (four axles and above). The Class 7C vehicles were further subdivided into, 7C1: Four – axle trucks, 7C2: Five – axle trucks and 7C3: Six – axle trucks. These vehicle classes were selected because of their significant axle loading and frequency of occurrence along Ekpoma Road. The traffic volume on the road was estimated in terms of equivalent single axle load (ESAL). An equivalent standard axle is defined as “a single axle caring a load of 80kn or 8.15tonnes spread over two set of dual tires, each set separated by 300mm (Parsley and Ellis, 2003; Osadebe and Quadri, 2021). Light vehicles and passenger’s cars are not considered in estimating the damaging effect of the traffic loading on the road because of little or no damage impact they have done on it. Axle loads were concerted to ESALs using the “fourth power rule”. Vehicle Damaging Factor or Axle Load Equivalency Factor (LEF or EF) of each vehicle was a determined using 1993 AASHTO Design Group procedures as follows:

$$EF = \left(\frac{Axle\ Load}{80TN}\right)^4$$

3.0 RESULTS AND DICUSSION

The summary of traffic characteristics on the road is presented in table 1. It could be observed from the table that a total of 694,023 vehicles were counted, indicating a total traffic volume on both directions. Motorcycles, passengers, cars, mini buses/pick – ups and heavy vehicles constituted about 6.3% (44,059), 37.9% (262,743), 19.9% (117,878) and 38.8% (269,343) of the total traffic volume respectively. The average daily traffic (ADT) and average heavy vehicles per day (AHV/day) were estimated to be 49,573 and 19,239 respectively.

TABLE 1: TRAFFIC CHARACTERISTICS ON EKPOMA AXIS OF BENIN – AUCHI ROAD

Type Of Vehicle	Iruekpen Junction		Abia Juction		Ujoelen (G2 Junction)		Ukpenu (Mosco Junct.)		Opoji Junction		Total	
	Benin bound	Auchi bound	Benin bound	Auchi bound	Benin bound	Auchi bound	Benin bound	Auchi bound	Benin bound	Auchi bound	Benin bound	Auchi bound
Motorcycles	4,320	4,126	2,610	3,120	4,022	3,692	6,213	6,038	4,821	5,097	21,986	22,073
Passengers car	29,461	30,643	21,461	20,128	27,864	28,583	24,874	24,031	28,216	27,482	131,876	130,867
Mini buses /pick – ups	13,040	12,872	11,668	12,432	10,893	10,634	11,218	12,031	10,994	12,096	57,813	60,065
Heavy vehicles	23,461	25,001	23,410	24,215	28,297	26,423	29,210	31,733	27,982	29,621	132,350	136,993
Ground Total											**344,025**	**349,998**

Total Traffic

Volume on both direction = 694,023

Average Daily Traffic (ADT) = 49,573

Total No. of Heavy Vehicle = 19,239

Overall Percentage of heavy vehicles = 38.8%

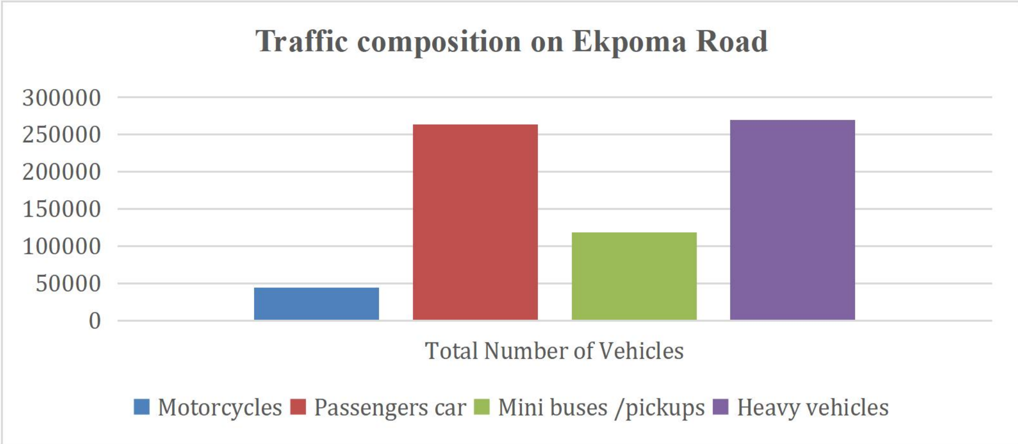

Fig 1: Traffic composition on Ekpoma Road (Field survey)

TABLE 2: DISTRIBUTION OF EQUIVALENT NUMBER OF VEHICLE AXLE LOAD ON EKPOMA ROAD ACCORDING TO AASHTO, DESIGN GUIDELINES, 1993

Category of Vehicle /no of axles	Code	Total load axle distribution (ton)	Total No. of vehicles		Load Equivalency Factor (LEF per vehicle)						Total Load Equivalent Factor	ESALs Benin Veh.	ESALs Auchi Veh.
			Benin Bond	Auchi Bond	**Axle 1**	**Axle 2**	**Axle 3**	**Axle 4**	**Axle 5**	**Axle 6**			
Truck 2 Axle	1-2	18	40,323	41,948	0.605	3.062					3. 67	147,836	153,793
Truck 3 Axle	1-2,2	26	21,988	23,328	0.165	2.633	2.633				5.43	119,387	126,663
Truck 4 Axle	1-2,2,2	34	18,853	20,599	0.152	2.436	1.175	2.436			6.20	116,862	127,684
Truck 4 Axle	1-2,2,2	34	19,440	18,390	0.152	2.436	1.175	2.436			6.20	120,500	113,992
Truck 5 Axle	1-2,2-2,2	42	17,128	17,008	0.145	1.640	1.640	1.640	1.640		6.71	114,870	114,065
Truck 6 Axle	1-2,2-2,2	45	14,618	15,720	0.092	0.969	0.969	0.969	0.969	0.969	4.94	72,150	77,540
												691,605	**713,787**

1 = S ingle Wheel single axle
2 = Double Wheel single axle
2, 2 = Double Wheel double axle
2, 2, 2 = Double Wheel triple axle

The Equivalent Single Axle Load (ESAL) on Benin bond = 691,605
The Equivalent Single Axle load (ESAL) on Auchi bond = 713,787
The Overall ESAL on Ekpoma Road = 1,405,392

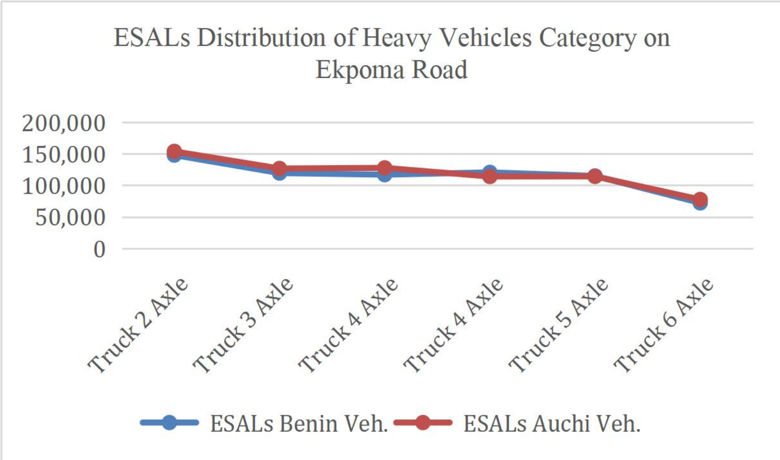

Fig. 2:ESALs Distribution of Heavy Vehicles Category on Ekpoma Road (Field Survey)

The total equivalent single axle load (ESAL) on the Benin – Auchi road (Ekpoma axis) was estimated at 694 over a 14day period, in accordance with the AASHTO 1993 Design Guidelines. Based on the analysis presented in Table 2, the average heavy vehicle traffic per day of 19,235 on this route had a load equivalency factor (LEF) of 3.06, indicating that each truck causes nearly three times the damage of a standard 80KN axle. This implies that, on average, every heavy vehicle on the Benin – Auchi road contributes approximately three times the Legal axle limit designated for Nigeria highways. This magnitude of impact is substantial and helps explain the accelerated deterioration observed on the route. This study also supports findings from the Federal Ministry of Works (FMW) axle and load draft report (2007), which concluded that coastal and southern roads experience heavier freight traffic than those in the hinter lands. These figures translate to truck proportion of 38.8% for Benin – Auchi road (Ekpoma axis). Similarly, the share of light vehicles was 61.2%. this high percentage of heavy vehicle traffic on the road likely accounts for its greater structural wear and more advance pavement deterioration related to roads in the northern regions.

4.0 CONCLUSION

An average Load Equivalency Factor (LEF) of 3.06 was estimated for each heavy vehicle plying the road. That is, each heavy vehicle that plies this road has same damaging effect as approximately three standard axle loads of 80KN. Obviously this road is over stretched as it is constantly subjected to loading beyond permissible legal limit of standard axle. The failures noticed on this road such as alligator cracks, potholes, depression, longitudinal cracks along the centre line were as a result of a combination of factors not limited to overloading from heavy trucks. Other factors could include; poor or unstable subgrade, subbase and asphaltic materials, lack of proper supervision, compaction delay, lack of proper maintenance culture to mention but a few. It is strongly recommended that the Federal Government in collaboration with relevant Road Transportation and Infrastructure Agencies, prioritize the installation and operation of weigh bridges at strategic locations long all major highways. Also, steps should be taken towards enacting legislation or policies that would explicitly criminalize the act of overloading.

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