Effect of Heavy Vehicles on Road Pavement and Implication on the Environment in North Central Nigeria

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ABSTRACT

Transport infrastructure plays a crucial role in Nigeria's economic development, mobility and environmental sustainability. Road pavement facilitates the movement of vehicles and ensure safe and efficient transportation of goods, services and people across the country. The study was conducted on Asa-dam Road Ilorin, Kwara State, Nigeria, primary source of data and random sampling techniques was employed to select 150 respondents. Findings from the study revealed that potholes, depression of the road surface and other road failures are caused by heavy vehicles. Majority of respondents (96.7%) perceived highest level of major damage are caused by heavy vehicles of 50 tons above while 45.3% perceived minor damage and 34.7% perceived medium damage by heavy vehicles of less than 30 tons. P-value of 0.000 is below the conventional threshold of $p<0.05$. R value of 0.892 with R^2 value of 0.795 implied a strong and positive relationship exist between inadequate road pavement and the environment which increases vehicle maintenance cost, travel time and pollution. F-ratio value of 140.832 was statistically significant. The study concluded that heavy vehicles have significant effect on road pavement damage as a result of the weight and of goods they carry therefore affecting the environment. However, it is recommended that the current road pavement be scrapped and new layer of asphalt be laid to cater for heavy vehicle traffic while government should do more routine and periodic maintenance of the road pavement.

Keyword: Heavy Vehicles, Road Pavement, Environment, Transport Infrastructure.

INTRODUCTION

Road infrastructure is one of the basic facilities needed for the development and growth of any modern economy. The growth of every country's economy is measured by the growth of the transport infrastructure in the country. No wonder the beauty of the advanced nations' economies can be quickly measured by the beauty of their transport facilities, while the stunted economy of the under-developed nations is easily visible in their pot-holed infrastructural system (Ede and Oshiga, 2014).

The level of provision of good and efficient road network spread in a nation defines the level of mobility of persons, goods and services within that country: more efficient the transport system, more prosperous the nation's economy. This is one of the principal factors that have made the development of tourism a very lucrative source of earning in nations that run a well-coordinated and more rational approach to the provision and maintenance of transport systems. Because of the importance of the provision of these facilities to the economy and the high cost involved, the onus for providing such facilities lies on the government. The management of the transport facilities can be through government departments or in collaboration with the private sector. Over the years, the Nigerian government has spent huge sums of money in the development of road infrastructure. Nigeria has the highest number of developed road network

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system in Africa estimated to cover over 200,000 kilometers (World Bank report, 2009). But the usefulness of these roads has been drastically reduced due to poor maintenance culture.

The decadence of the Nigerian roads emanates from poor designs and untidy execution of the road projects. This is mostly typified in the provision of inadequate drainage system that gives rise to potholes, erosion of the roads and other avoidable defects that continue to destroy the road network systems. These problems translate to high cost of goods and services, high death rate due to fatal accidents on the bad roads and the high loss of man-hour in traffic. Ultimately, these culminate into a vicious cycle of hyper-cost of production, low productivity, escalating inflation, unemployment and a stagnating economy. No wonder Nigeria is gradually becoming one of the costliest nations to live in on the face of the earth.

Heavy and over-weight vehicles are widely believed to be a major cause of highway degradation, and their damaging effects make it evident that trucks are the primary cause of traffic-related highway deterioration (Olufemi et al, 2021). Nigeria has the status of a developing country where road facilities are grossly inadequate to carter for the teeming population of road users (Agbonkhese et al., 2013). There are many potholes and detours on most Nigerian roads and this means that vehicles keep breaking down so that on many of Nigeria's roads emergency mechanics have sprung up to assist stranded commuters sometimes with disastrous consequences. Apart from disrupting the smooth flow of traffic, the dug up roads in the city are also adding to the financial burden on citizens (Enwerem et al, 2016).

The road transportation system in Nigeria is as old as creation. During the 1900s under the British colonial rule, the road designed was to aid the transportation of goods from village to hinterlands to the coastal region for exportation of raw materials for their industries in U.K (Sheriff, 2009, as cited in (Project Reserve, 2020). However, during evolving economic development after independence in 1960 saw the need for road system expansion with the main purpose of facilitating access to the cities and large towns (Encyclopedia of nation, 2008). Currently, road system is about 208,200km with 28,980km paved and 179,220km unpaved (Federal Ministry of Works Bulletin, 2012) as cited in (Project Reserve, 2020).

A nationwide road survey conducted by the Central Bank of Nigeria (CBN) on the state of highways in the country in December 2002 reveals that the road network as of December 2002, was estimated at 194,000km. It shown that most of the roads were in a bad condition, especially those in the southeastern and northwestern part of the country. The pattern is generally the same for the roads in other part of the country. Some of the roads, constructed over 30 years ago, had not been rehabilitated even once, resulting in major cracks (longitudinal and transverse), depression, broken down bridges and numerous potholes that makes roads transport slow and unsafe (CBN, 2002).

The survey also shows that the state of Nigeria roads has remained poor for a number of reasons. Such reasons include faulty designs, lack of drainage and very thin coatings, which was easily washed away, excessive use of the road network by heavy vehicles, given the underdeveloped nature of waterways and railways, which could serve as alternative means of transport, absence of an articulated road program and inadequate funding for road maintenance (Odugbemi, 2010) as cited (Project Reserve, 2020).

Trucks are a major consumer of the road infrastructure especially because they apply the highest loads to the road surface although not heavy trucks cause equal damage because of variations in wheel load (static and dynamic), number and location of axles, types of suspensions, number of wheels, tyre type and inflation pressure, and other factors. Regulation of the trucks permitted to use the highway and apportionment of costs to vehicles in accordance with road wear should be based upon a thorough understanding of the way in which trucks interact with and damage pavements (Gillespie et al, 1992). Optimization of design and maintenance practices is dependent upon careful consideration of the heavy vehicles that use the roadway. Heavy trucks are increasing in the diversity of their design and use. New configurations, new suspensions, new tyre types, and higher inflation pressures are changing the loads imposed on the pavement surface.

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Although relevant truck properties (weights, axle loads, dimensions, etc.) are regulated, it has been recognized in recent years that there is a lack of detailed or conclusive information on characteristics of heavy vehicles relevant to pavement longevity. Ther is need for detailed understanding of the interaction of trucks with the pavement structure so as to rational regulation of truck traffic, particularly with respect to acceptance of new designs and innovations in vehicle configurations.

CONCEPTUAL REVIEW AND THEORETICAL FRAMEWORK

Road surfaces (or pavements) may be classified as flexible, composite or rigid. A flexible pavement consists of one or more layers of flexible (asphalt) material supported by a granular subbase. The relative damage to a pavement caused by heavy trucks is dependent on vehicle, tyre, and pavement factors. In order to understand the relative damage potential of a truck, the vehicle and tyre characteristics that are relevant to pavement damage must be understood along with the design variables that effect a pavement's resistance to damage induced by truck wheel loads. The wheel loads of heavy trucks contribute to various forms of pavement distress such as fatigue (which leads to cracking) and permanent deformation (rutting), (Gillespie et al, 1992, as cited in Yiqao et al, 2022).

Road transport is the most resilient mode of transport in Nigeria after the collapse of the rail transport system in the early 1980s. Road transportation accounts for over 90% of freight and passenger services for Inland transportation and therefore the importance of the inland road network as a significant contributor to the social, economic development of the country (Oyekanmi et al, 2020). Indeed, the Nigerian roads cannot stand the test of time and durability because, the roads are used by heavy duty trucks and vehicles, which was not the original design and conception of most of Nigerian roads. Most Nigerian roads are built and constructed for light vehicles but heavy duty trucks and vehicles with so much loads are allowed to use these roads.

As the economy grows, the growth of passenger transport and freight transport grows accordingly and calls for a massive demand for additional vehicles and a new network of roads and indeed need for better roads. The significant increase in traffic volume has resulted in the tendency of operators to overloading their vehicles to reduce operational cost. Overloading of trucks is now a familiar scene on Nigeria roads, and it is not surprising to see vehicles carrying as much as twice the legally permissible axle loads on the roads. The road network in Nigeria comprises of Federal, states and local government roads. The investment of the Government on road infrastructure has been increasing since independence. The current value of Nigeria road asset is considerably high at an estimated cost of about N3.4 trillion as of March 2018 (Oyekanmi et al, 2020).

Road pavement

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). The pavement reduces the stresses on the sub-grade to such a level that the sub-grade does not deform under the action of traffic (Rolt and Parkman, 2000).

Traffic on a road pavement is characterized by a large number of different vehicle types and these can be considered in pavement design by using truck factors to transform the damage they apply to the pavement to the damage that would be applied by a standard axle (Pais et al, 2013). The vehicles/Axles cause significant damage to the pavements, increasing the pavement construction and rehabilitation costs (Pais et al, 2013). High truck loads, load configurations and the number of trucks also lead to pavement deterioration necessitating load limitations and early replacement (Zaghloul & White, 1994, as cited in Pais et al, 2013).

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue II February 2024

As the primary functions of a pavement is load redistribution, representative loading characteristics must be presumed about the expected traffic it will encounter in order to adequately design a pavement. Vehicular loads exerted on the pavement can be characterized by the following parameters: tyre loads, axle and configurations, typical axle load limits, repetition of axle loads and traffic projection.

Truck Characteristics affecting pavement damage

According to Gillespie et al (1992) as cited in Nasradeen & Roslan (2018), fatigue damage to flexible pavements is most directly determined by maximum axle loads and pavement thickness. Other vehicle properties have a smaller, but still significant, influence on fatigue. The relationships between damage and certain truck properties of interest are discussed below:

- **Axle loads:** Fatigue damage is dominated by the most heavily loaded axles because of the power-law relationship of load and fatigue. When a loaded axle moves along a pavement it deflects the pavement downward creating a deflection basin. The deflection creates short-duration stresses and strains which fatigue the pavement structure and add incrementally to permanent deformation (rutting).
- **Tyre inflation pressure**: Elevated tyre inflation pressure greatly increases the fatigue damage of flexible pavements. Over-inflation of conventional tyre by 25 psi nearly doubles flexible pavement fatigue. Similarly, over-inflation of wide- base single tyres is especially critical, increasing fatigue by a factor of four.
- **Tyre configuration**: Of the various tyre configurations used on trucks, the most significant to damage is the heavily loaded conventional tyre on steer axles. Single tyres, typically loaded to 12 kips, cause the steer axle to be more damaging in fatigue and rutting to flexible pavement than a 20-kip axle (the current legal limit) with dual tyres. Steer axle loads should be reduced to 11 kips or less to eliminate this disparity.
- **Tandem suspensions**: Theoretically, tandem axles have the potential to be no more damaging to roads than single axles with equivalent load per axle (i.e. a 36-kip tandem can be no more damaging than two 18-kip singles). On rough and moderately rough roads, walking-beam suspensions (without shock absorbers) are typically 50% more damaging than other suspension types.

Of the truck properties discussed above, axle loads have the greatest influence on fatigue damage of flexible pavements. However, flexible pavements may also be damaged by **rutting**. The permanent deformation of the asphalt concrete layer caused by a vehicle is directly dependent on its gross vehicle weight, To the extent that freight must be carried by trucks, rutting cannot be alleviated by regulating truck gross weight, because lower weight limits will only put more trucks on the road to meet commercial hauling needs. The horizontal component of the vertical load will push the wheel toward the lowest part of the rut, resulting in manifesting a rutting or increasing the severity of rutting (Gillespie et al, 1993 as cited in Mohsen et al, 2022).

Vehicle factors influencing pavement damage

Speed

According to Gillespie et al (1992) as cited in Michael & Wynand (2020), Speed is one of the most important factors influencing pavement damage arising from dynamics of a vehicle. The presence of the dynamic component of wheel loads elevates the mean value of fatigue damage along the pavement and is capable of elevating fatigue at the most severely loaded locations by a factor of more than 2 in some cases. The influence of speed on dynamic wheel loads is well understood, but complex. When considering the dynamic response of a vehicle to road irregularities, the factors of speed and road roughness are inseparable. The speed determines how the roughness of the profile is “seen” by the moving vehicle. If dynamic loads are spatially repeatable among trucks, the most severely loaded locations will wear much more quickly than

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue II February 2024

they would if the dynamic loads are randomly distributed as a result of dynamic variations among trucks (Gillespie et al, 1992). Speed alone has an effect unique to damage of flexible pavements. Higher speeds reduce the time duration of wheel load on a given pavement location.

Gross Weight

In the public eye, there is the perception that large trucks damage the road system by virtue of their weight. However, analyses of the damage mechanisms show that gross weight is not directly linked with fatigue damage of either rigid or flexible pavements. That is, it is not the total weight of the truck that "breaks-up" the road, but rather it is high axle loads. High gross weights can be tolerated by the road system if distributed uniformly among a sufficient number of axles (Gillespie et al, 1992, as cited in Nasradeen & Roslan, 2018).

Maneuvering

Maneuvering of trucks can also lead to increased pavement fatigue by temporarily shifting load among axles. During acceleration the load shift onto rear axles is small enough that the influence on pavement fatigue is generally insignificant. Load transfer onto front axles during braking affect flexible pavements localized fatigue damage could increase by as much as 100% to 1000% depending on the severity of braking (Gillespie et al, 1992, as cited in Donia et al 2022). It should be noted, however, that the reduction in speed strongly increases rutting, such that rutting will increase in locations where trucks routinely slow or stop. Cornering increases pavement fatigue and rutting by shifting the load to one side of a vehicle. Wheel loads on one side of the truck might typically increase by 20%, causing a 100% increase in fatigue and a 20% increase in rutting (Gillespie et al, 1992).

Failure Types along Nigerian roads

Some common Failure types along Nigerian roads as identified by Afolayan & Abidoye (2020) are:

1. Edge Failure
2. Cracks and Potholes
3. Failed Drainage
4. Asphalt surface.

Other failures identified by (Ndefo, 2012) includes: Potholes and Cracks, Depression on road surface, Development of Gully due to erosion, failed road shoulders, Faulty Drainage, Faulty Traffic signals and Street lights and Wiping off of Lane markings.

Socio-Economic Impacts of Potholes

Potholes are one of the factors that hinder the free movement of goods and persons in Nigeria. The potholes nature of the Nigerian roads can be a serious disincentive for both local and foreign investment in the country. This is due to the fact that potholes (bad roads) can be a serious constraint to productivity This infrastructure decay or deficiencies can as well reduce drastically the productivity of firms and households or individuals and this can directly affect the productivity of the Nigerian economy, especially in this recessionary period (World Bank, 1992; Otegbalu, 2011, as cited in Ukdiss 2021).

Bad roads as a result of potholes in the cities can disconnect and prevent the cities in playing their key role in the evolution of national and global economies. This is because a city act as a catalyst for the generation of vast wealth and is the engine room of the national economy. So, potholes or bad roads in the Nigerian cities have a direct correlation with the Nigerian economy as a whole. This is anchored on the fact that the strength and growth of the Nigerian economy, "the Contact Point of international economies, the health of

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue II February 2024

our democracy and the vitality of the humanistic endeavors are all dependent on whether the city works (Ogbolu, 2011, Larless, 1996, as cited in Ukdiss 2021).

The implication of this is that where the roads in the cities of Nigeria are bad with potholes, the economies of these cities will be negatively affected, and this will pull down the performance of the national economy. Again, the cities are where the seaports, railway stations and airports are, and so function as contact points for international businesses and investments. Therefore, where the cities roads have so many potholes, there is the tendency that international businesses and investors will be discouraged to come into these cities. When this happens, there can be disinvestment and this can affect the growth and performance of the economies of these cities and the national economy will equally nose-dive southward (Business Bliss Consultant, 2018). This is because transportation plays a pivotal role in economic development of the cities and the nation.

Road transportation provides essential services to both businesses and households or the individuals within a given geographical area and this facilitates the movement of goods and persons, which are very crucial and vital in the operation of the market economy. So, road infrastructure is the key to urban transportation according to Otegbolu (2011) as cited in Ukdiss (2021), and this is what determines whether a particular place could be developed or not. This also determines whether people can live in a particular place or not and so serves as a catalyst for the development of urban centres.

Equivalent Single Axle Load (ESAL) Theory

This theory is based on the concept that different axles have different impacts on the pavement. ESAL is a hypothetical single-axle load that is used to represent the cumulative damage caused by a series of axles of varying weights and configurations. It is commonly used to calculate the design life of a pavement (Wang and Yu, 2019). This theory has significant implications for Nigeria's road infrastructure because of the high volume of heavy vehicles, especially trucks and tankers, that ply the country's roads. ESAL can be used to design pavements that can withstand heavy vehicle traffic and reduce the need for costly repairs and maintenance (Adeyemi and Adeyemo, 2020).

Damage Factor Theory

This theory is based on the concept that the damage caused by a vehicle is proportional to the fourth power of its axle load. This theory is commonly used to calculate the pavement damage caused by heavy vehicles (Zeng et al, 2021). This theory has implications for Nigeria's road infrastructure, given the high volume of heavy vehicles that ply the country's roads, causing significant damage to the pavements. Understanding the damage caused by heavy vehicles is crucial for designing durable pavements that can withstand heavy traffic (Adeyemi & Adeyemo, 2020).

Overall, the effect of heavy vehicles on road pavement is a complex and multifaceted issue that requires consideration of several factors, including the type and weight of the vehicle, the pavement structure and materials, and the traffic volume and patterns. The implications of heavy vehicle traffic on the Nigerian environment and road infrastructure can be addressed by implementing appropriate pavement design methods, monitoring and regulating the weight of heavy vehicles, and enforcing weight restrictions on roads.

METHODOLOGY

Asa-Dam Road is located in Ilorin-West Local Government of Kwara State. Kwara state is a state in western Nigeria bordered to East by Kogi State and to North by Niger State and to the South by Ekiti, Osun and Oyo States. While its western border makes up part of the international border with Benin Republic. Kwara State is the 9th largest state of the Federal Republic of Nigeria with approximately 3million people on 37,000km

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue II February 2024

of land centrally located and such a major trade route between the commercial centres of Northern and Southern Nigeria. Kwara State is known for its agricultural activities with crops such as maize, cassava, yam, rice and sorghum being major produce. Also significant amount of livestock farming including poultry, cattle, goat and sheep farming. There are several manufacturing industries in the State including Flour mills, Steel company, beverage production, pharmaceutical companies, textile and food processing. Markets and shopping centers are located in different parts in Ilorin the state capital as well as service providing sectors such as banking and finance, transportation, telecommunication and hospitality.

The population of the study consists of all heavy vehicles plying Asa- Dam road, road side user and residents of Asa-Dam, Ilorin, Kwara State. Traffic count was conducted during the hours of 8:00am to 6:00pm on weekdays for one week, from the observation more than 500 heavy vehicle ply the road within the period of observation, 150 heavy vehicles that fall within the specification of the research were randomly selected, this forms the sample size for the study. In addition, based on roadside survey, nothing less than 1,000 people use the road per day. A sample of road users was randomly selected to determine the effect of heavy vehicles on health which is measured in terms of its effect on the body (headache, back pain, stress, depression) in the study area. The environment is measured by the effect of the heavy vehicles on the road pavements in terms of depressions, potholes, congestion and pollution.

Model Specification

$$\mathbf{Y=a+b_1X_1 + b_2X_2 + b_3X_3 + ... + b_nX_n + e}$$

Where:

Y = Environment (E)

$a_{0 =}$ Constant

b_nX_n = Regression coefficients

X_1 = *Vehicle Maintenance (VM)*

X_2= *Travel Time (Tt)*

X3 = *Pollution (P)*

X4 = *Health*

e = error term or residual

RESULTSAND DISCUSSION

Effects of load capacity of heavy vehicles on level of road pavement damage.

Table 1 shows that 45.3% of the respondents are of the view that heavy vehicles of less than 30 tons causes minor damage to the road, 34.7% said it causes medium damage while 20% of the respondents said heavy vehicles of less than 30 tons causes major damage to the road.

This table also shows that 1.3% of the respondents believes heavy vehicles of 30 tons to 50 tons have minor damage on the road pavement, 28% of the respondents said they have medium damage on the road pavement while 70.7% of the respondents believes they cause major damage to road pavements. It was also gathered that, 3.3% of the respondents are of the view that heavy vehicles of 50 tons above have medium

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue II February 2024

damage on the road pavements, while 96.7% of the respondents believes heavy vehicles of 50 tons and above have major damage on the road pavement. This result shows that heavy vehicles of 50 tons above causes the highest level of major damage on the road pavement while heavy vehicles of less than 30 tons causes minor to medium damage.

Table 1 Level of damage

Level of damage	**Frequency**	**Percentage (%)**
Heavy vehicle of less than 30 tons		
Minor	68	45.3
Medium	52	34.7
Major	30	20.0
Total	150	**100**
Heavy vehicle of 30 tons to 50 tons		
Minor	2	1.3
Medium	42	28.0
Major	106	70.7
Total	150	**100**
Heavy vehicles of 50 tons above		
Minor	0	0.0
Medium	5	3.3
Major	145	96.7
Total	150	**100**

Source: Field survey, (2023)

The table below shows that 44.7% of the respondents strongly agreed that potholes and depression of the road surface is as a result of heavy vehicles, 51.3% of the respondents agreed while 4% of the respondents disagreed. This result shows that majority of the respondents agree to the fact that potholes and rutting is caused by heavy vehicles.

Table 2 Effect of heavy vehicles on road pavement

Potholes, depression of road surface is as a result of heavy vehicles	**Frequency**	**Percentage (%)**
Strongly agree	67	44.7
Agree	77	51.3
Disagree	6	4.0
Total	150	**100**

Source: Field survey, (2023)

The effect of inadequate road pavement on the environment

In this study, some specific variables were estimated to the inadequate road pavement affecting the environment. The regression summary shows that all the independent variables such as Health, Travel time, Vehicle maintenance and Pollution have positive relationship with the environment. The multiple regression model indicates that R have the value of 0.892 while R^2 is 0.795 and P is 0.000; this implied that the extent

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue II February 2024

to which the predictor variables explained the variation in the dependent variable was 79.5% meaning there exists a strong and positive relationship between inadequate road pavement and the environment.

Table 3 presented the coefficient of the effect of inadequate road pavement on the environment. It was revealed that three out of the four independent variables were significant at 0.05 level of significance. These variables are vehicle maintenance with a beta value of 0.185, t-value of 2.089 and p-value of 0.038. Travel time had beta value of 0.429, t-value of 7.654 and p-value of 0.000. Pollution had a beta value of 0.262, t-value of 2.859 and p-value of 0.005. Of all significant independent variables, travel time made the largest contribution of 0.429.

E= 0.185VM + 0.429Tt + 0.262P

This model implies that the effect of heavy vehicles on road pavement majorly affects travel time, vehicle maintenance and impair travel time, it shows that it has no significant effect on health(beta value 0.78. t – value of 1.154; P-value of 0.251) as health is measured in terms in terms of effect on the body.

Table 3 Model summary of the effect of inadequate road pavement on the environment

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.892[a]	.795	.790	.345

a. Predictors: (Constant), Health, Travel time, Vehicle maintenance, Pollution

Source: Field survey, (2023)

Table 4 Coefficients of the effect of inadequate road pavement on the environment.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.111	.145		.768	.444
	Vehicle maintenance	.183	.088	.185	2.089	.038
	Travel time	.711	.093	.429	7.654	.000
	Pollution	.289	.101	.262	2.859	.005
	Health	.078	.067	.143	1.154	.251

a. Dependent Variable: Environment

Source: Field survey, (2023)

Relationship between damaged road pavement and transport cost

The analysis of the correlation as presented in table 4.5 below was adopted. It was revealed that the Pearson Product Moment Correlation (PPMC) value between damaged road pavement and transport costs generated was 0.809 which implied that there is a maximum correlation between damaged road pavement and transport cost. Increase in transport cost such as cost of fueling, vehicle maintenance and repairs and cost of tyres influenced by the damaged road pavement. With the critical p-value between damaged road pavement and transport cost was 0.000 which was lower than 0.05 level of significance. This implies that there is a

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue II February 2024

positive, strong and significant relationship between damaged road pavement and transport cost.

Table 5 Correlation between damaged road pavement and transport cost

Correlations			
		Damaged road pavement	Transport cost
Damaged road pavement	Pearson Correlation	1	.809**
	Sig. (2-tailed)		.000
	N	53	53
Transport cost	Pearson Correlation	.809**	1
	Sig. (2-tailed)	.000	
	N	53	53

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field survey, (2023)

Validity of the test

Anova F-ratio was used to test the validity of the effect of heavy vehicles on road pavement, this result shows that F ratio value of 140.832 was statistically significant at 0.05 level of significance which implies that there is a significant impact of heavy vehicles on the the road pavement, this also validates the developed model.

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	66.995	4	16.749	140.832	.000[b]
	Residual	17.245	145	.119		
	Total	84.240	149			

a. Dependent Variable: Environment

b. Predictors: (Constant), Health, Travel_time, Vehicle maintenance, Pollution

CONCLUSION

The study revealed that heavy vehicles have a significant impact on road pavement damage as a result of their weight and the weight of goods they transport. This has led to major deterioration of the road pavements and caused road failures such as cracks and potholes, depression on road surface (rutting), failed road shoulders and faulty drainages on Nigerian roads. Majority of the road pavements in Nigeria are old and unable to withstand heavy vehicular traffic.

Also, it was revealed that damaged road pavement over the years have continued to increase vehicle maintenance costs which account for 48.67% of the total respondents and increase travel time of respondents which account for 71.3% of the total population, air pollution and noise pollution. The findings also shows that there is a level of insignificant effect on road users such which can be further looked into in further studies where other factors can be analyzed to identify the gap between the effect of heavy vehicle

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue II February 2024

on the health of road users this study. Furthermore, the poor condition of the road pavement has increased the cost incurred in terms of fueling, maintenance and repairs and tyres making transport cost expensive.

In conclusion, heavy vehicles damage the road pavement thereby adversely affecting the environment. The increased pavement damage resulting from heavy vehicles not only lead to increase vehicle maintenance cost, longer travel time but it also contributes to pollution and its associated health risks. Additionally, it increases the overall transport cost such as cost of fueling, tyres, maintenance and repair costs.

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ANNEXURE

The effect of heavy vehicles on road pavement

Instruction: Indicate your option by ticking the appropriate boxes.

S/No	Statement	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	Heavy vehicles have significant impact on road pavement damage?					
2.	Weight of heavy vehicles and goods they carry are the major causes of damage to roads?					
3.	Potholes, depression of the road surface is as a result of heavy vehicles?					
4.	Current road pavement is inadequate to withstand heavy vehicle traffic?					
5	Good road pavement provide easy and smooth movement?					

		Minor	Medium	Major	
6.	Level of damage caused by heavy vehicles of less than 30 tons				
7.	Level of damage caused by heavy vehicles of 30 tons to 50 tons				
8.	Level of damage caused by heavy vehicles of 50 tons above.				

The Effect of inadequate road pavement on the environment

Instruction: Indicate your option by ticking the appropriate boxes.

S/No	Statement	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
9	Damage road pavement increases the cost of vehicle maintenance?					

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue II February 2024

10.	Inadequate road pavement increases travel time?					
11.	Environmental impact such as air pollution and noise pollution are caused by heavy vehicles?					

12. What kind of impact does damage road pavement have on you? (a) Headache [ ] (b) Backache [ ] (c) Hypertension [ ] (d) Stress [ ] (e) Others [ ]

13. Which of these do you incur cost mostly? (a) Fueling [ ] (b) Maintenance & Repairs [ ] (c) Tyres [ ]

The relationship between damaged road pavement and transport cost

Instruction: Indicate your option by ticking the appropriate boxes.

S/No	Statement	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
14.	Damaged road pavement increases transport cost?					
15.	Transport cost on route with damaged road pavement is expensive?					
16.	How would you rate the present road in terms of comfort, safety and road smoothness?					