EVALUATION OF THE IMPACT OF FLEXIBLE AND RIGID PAVEMENTS ON HIGHWAY NOISE POLLUTION

BY

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CERTIFICATION

This is to certify that this work was carried out by **UGEH OSAGIE PHILIP**, **Mat.No. ENG1804907**, of the department of Civil Engineering, Faculty of Engineering, University of Benni City, Edo state, Nigeria.

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DEDICATION

I dedicate this work to the department of Civil Engineering for their impactful knowledge in the course area since I was admitted 5 years ago.

ACKNOWLEDGEMENT

I would like to express my heartfelt gratitude to everyone whose unwaving support and essential contributions have shaped the course of this project on the evaluation of the impact of flexible and rigid pavement on highway noise pollution.

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ABSTRACT

Road traffic noise is a harmful environmental pollutant that affects public health. Reducing the tire pavement noise by appropriate design of a durable pavement may reduce the road traffic, case study shows result shows that reducing the nominal aggregate size (NMAS) from 19.0mm to smaller value had a noticeable impact on the perceived noise from car traffic, the incorporation of seashell in OGAC (open graded asphalt concrete) can reduce the tire pavement noise by low frequencies. It has been observed also that rigid pavement makes more noise than flexible pavement.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF STUDY

Pavement is a hard surface that is laid down on the ground, usually for people to walk or drive on. Pavement materials are the materials that are used to construct a pavement, examples of such materials are; concrete, asphalt and so on. Highway noise pollution refers to the Sound produced by traffic on highways, which can have negative impact on the environment and people's health. Evaluation is a way of assessing something, like the impact of different Pavement materials on highway noise pollution.

The sources of tire-road noise are mainly divided into three categories: the noise generated by the equipment components during operation of the vehicle the aerodynamic noise generated by the interaction between the car body and the surrounding air, and the tire-road noise generated by the interaction between the tire and the road surface, which has become the main source of noise for high-speed vehicles.(Ling etal.,2021). With the introduction of electric vehicles, which have an electric motor instead of an internal combustion engine and therefore produce little motor and no exhaust noise, the share of tire-pavement noise in the road traffic noise is expected to further decrease. Reducing the tire-pavement noise, therefore, may help to improve the health of the public. Recently, there has been a research body in the pavement community that investigated the impact of pavement type and surface conditions on the tire-pavement noise (Sakhaeifar, M., et al. 2018).

However there are also recommendations on the design of pavement surface mixtures to improve the acoustic performance of pavements. For example, it is generally agreed upon that placing a thin layer of porous asphalt mixture at the pavement surface may result in so-called “quiet pavement” (Ramussen et al., 2007). Research efforts have been continued to evaluate the relationship between various design parameters and acoustic performance of asphalt mixtures and to him suggest modifications to their designs for an optimal balance among acoustic performance, permeability, durability, and other desirable pavement surface properties (Smit, A., et. al . 2016) Meanwhile, pavement construction consumes large quantities of nonrenewable resources such as good-quality natural aggregates, whose excavation and processing have not only consumed large amount of energy but also generated negative environmental impact. Replacing virgin aggregates with renewable or waste materials, such as recycled concrete aggregate, slag, reclaimed asphalt pavement, seashell, and other alternatives, has become a major interest and practice in the pavement community (Nguyen, D. H., et. al 2017). In the documented research efforts, on one hand, the impact of pavement surface mixture on road traffic noise was mainly evaluated by

(Berglund, B., and T. Lindvall.. 1995) direct measurement of the noise inthe field either near the tire-pavement interface or at the roadside, (Park, T. et. al, 2018) indirect characterization through the measurement of mixture acoustic properties (e.g., sound absorption coefficient) in the laboratory.

Noise pollution is known as a major problem for the quality of life in develoed areas all over the world (ElifEbru and Emin, 2011; Oayinka,et al. 2012).Due to the increase in the number of cars and industrialization, noise pollution has also increased. Noise in cities has reached up disturbing levels. Residences far from noise sources and near silent secondary roads are currently very popular. People prefer to live in paces far from noisy urban areas (Serkan et al., 2009). There are many factors that may affect sound emission in the space; hence, numerous models have been developed in this area so far. Some of these models are described in this reference (Garg and Maj, 2014). Most of them are physical factors which cover sound properties. Measuring and examining such parameters is very dfficult and complicated. However, other parameters including traffc-related ones such as velocity of vehicles and traffic flow are measured very easily (Ranjbar et al., 2012).

1.2 PROBLEM STATEMENT

Noise is a major source of noise pollution, and it has been linked to a number of negative effects, including increased stress levels, sleep disturbances, and cardiovascular diseases. In addition, highway noise can cause annoyance and decrease quality of life for those living near highways.

However, there is a limited research on the effectiveness of different types of pavement in reducing noise pollution. Therefore, a need exists for a comprehensive evaluation of the impact of rigid, flexible and composite pavement on noise pollution, in order to identify the most effective solutions for reducing noise pollution from highways.

1.3 AIM AND OBJECTIVES

The aim of this research is to evaluate the impact of different types of pavement, including rigid, flexible, and composite pavements, on noise pollution.

The objectives of this research include;

To compare the noise measurement results from rigid, flexible and composite pavements and to compare the data gotten from the field with code specification.

To analyze the impact on each types of pavement on the environment.

To analyze the sound produced from each type of pavement

To analyze the sound produced based on classification of vechicles.

1.4 SCOPE OF STUDY

For this project, the scope of study would include the following:

The types of pavement to be studied, which are rigid, flexible and composite pavement; how they are constructed in terms of their structure from their foundation.

The locations where the noise measurements will be taken, which are flexible and rigid and composite pavements, in terms of co- ordinates.

The methods used to measure and analyze the noise levels produced by different pavements, in term of decibel.

1.5 JUSTIFICATION OF STUDY

The justification for this study is that highway noise pollution is a major environmental and public health issue that has not been adequately addressed in many countries.

Although there has been some research on the factors that affect highway noise pollution and the technologies that can be used to reduce it, there is still a need for further research on the impacts of different pavements on highway noise pollution.

This study aims to fill this gap in the literature by evaluating the impact rigid flexible and composite pavement on highway noise pollution. This research is important because it can help to inform the development of policies and strategies to reduce highway noise pollution, by understanding how highway noise came about.

CHAPTER TWO

2.0 LITERATURE REVIEW

Highway noise pollution has become a significant concern due to its adverse effects on public health and quality of life. Noise pollution is primarily generated by the interaction of vehicle tires with the pavement surface. As such, the selection of appropriate pavement materials plays a crucial role in mitigating noise levels. This literature review aims to evaluate the impact of different pavement materials on highway noise pollution, focusing on studies that have investigated the acoustic characteristics and noise-reducing properties of various materials.

Hence, to check for the connection between asphalt surface combination plan and noise perceived by the general population and their wellbeing, the noise examined in this study is restricted to the tire-asphalt noise, while other source commotions (e.g., streamlined, engine and fumes noise) are out of degree. Three parts of writing were checked on in relating blend plan to apparent clamor and general wellbeing: pavement surface combination plans for low tire pavement noise and estimation/expectation of tire pavement commotion, road traffic noise models, connection between traffic clamor and its effect on the general wellbeing. The utilization of shell in asphalt and other designing applications is likewise evaluated in this segment.

2.1 ACOUSTIC CHARACTERISTICS OF PAVEMENTS:

To evaluate the impact of rigid flexible and composite pavement on noise pollution, it is essential to understand their acoustic characteristics. Numerous studies have investigated the acoustic properties of different materials, including asphalt, concrete, rubberized asphalt, and porous pavements. It has been perceived that asphalts related with lower tire-asphalt clamor for the most part have the following highlights in the surface material: little and negative surface, high air void content (or porosity), and low stiffness (Ramussen et al., 2007).

However black-top cement surface is for the most part calmer than Portland concrete substantial surface and most of cleared streets in the U.S. have black-top substantial surface, this audit centers around black-top blends utilized for the asphalt surface, and specifically, permeable black-top combinations. The most usually utilized combination type for black-top asphalt surface is thick evaluated black-top cement (DGAC), which includes a low air void content (about 48%) and a total degree that streamlines the combination thickness. This sort of blend, nonetheless, doesn't have a huge acoustic advantage as opposed to open-or whole evaluated black-top mixtures (Ramussen et al., 2007). There have been a few endeavors to change DGAC plans for better acoustic execution while still keeping up with its mechanical solidness. Semi-dense asphalt concrete, which has an air-void content of 12 to 16 percent and is used in Switzerland and other European nations, is one product of these efforts (Poulikakos et al 2022). Black-top mixtures of hole total degree are frequently calmer than DGAC due to their ideal surface texture, and the utilization of more modest most extreme total sizes frequently prompts a further lower tire-asphalt noise (Vázquez, et al, vol 9). Stone mastic asphalt (SMA) mixtures (Ling,S, et al 2021), ultra-thin wearing course (UTWC) mixtures (Cui, et al vol13), and thin overlay mixtures (TOM) are all examples of this kind of mixture. Whole reviewed black-top cement, not withstanding, frequently has a low air void substance that is tantamount to that of DGAC. Its sound decrease capacity, in this way, is by and large lower than that of open evaluated black-top concrete (OGAC) (or permeable black-top cement [PAC]) of a comparable greatest total size (Loss. M. et al 2013). Both field perceptions and research facility tests have shown that asphalt surfaces built with OGAC for the most part have a lower tire-asphalt commotion than asphalts of thick or hole evaluated surfaces (Lu, Q., and J. Harvey.2011, Lu, Q., E. Kohler,2009). OGAC or PAC includes a high air-void substance, normally in the scope of 18- 26% (Alvarez, A. E. et al.2006).

Also the high porosity has restricted the help life of OGAC to a brief length (7-10 years) (Lu, Q., et al ,2009), yet research has shown that a blend of techniques like lessening the most extreme total size and utilizing altered black-top binder(e.g., black-top rubber, epoxy black-top) may fundamentally improve it (Lu, Q., and J. Harvey.2011, Luo, S.2014). To portray the acoustic exhibition of a blend, the most well-known approach is commotion estimation, either straightforwardly in the field on or close to an asphalt surface, or by implication in the research center on compacted combination examples. Field estimation strategies incorporate wayside estimations and (Ramussen et al., 2007). Wayside measurements are taken at the side of a road using receivers that record traffic noise or microphones that are set at a pre-determined distance from the road. Contingent upon the volume of traffic and information on vehicle type, speed, and tire type, wayside estimations can be arranged into three kinds: factual cruise by (SPB), controlled cruise by (CPB), and constant stream traffic time coordinated model (CTIM). The greatest sound levels (Lmax)of person vehicles are estimated in SPB and CPB while a typical identical sound level (Leq) is determined in CTIM.The source estimations in the field are performed close to the tire-asphalt point of interaction to record the tire-asphalt commotion.

There are two methods for source estimations: on-board sound force (OBSI) and closeness (CPX). The OBSI measures sound intensity with two microphones near the tire-pavement interface of a standard reference test tire (SRTT), while the CPX measures sound pressure with one microphone near the tire-pavement interface (Ramussen et al., 2007). The OBSI test does not typically take place in an enclosed trailer, whereas the CPX test does. The acoustic absorption, macro texture, and air void content (also known as porosity) of compacted mixture specimens are the main properties that are measured in the laboratory and used to characterize the properties that affect tire-pavement noise. Acoustic retention is normally estimated on a round and hollow example set in an impedance tube as per ASTME 1050 (ASTM E1050-19.2019). Macrotexture can be estimated utilizing a sand fix strategy (ASTME 965) (ASTME1050-19.2019) or laser-based level sensors. Air-void substance is determined from the mass explicit gravity and the hypothetical greatest explicit gravity of a compacted example. Observational (factual) models have been created in different examinations to connect estimated commotion to combination boundaries (e.g., blend type, modulus, folio type, total degree, macrotexture) utilizing field estimations of clamor on in-administration asphalts or test areas of pavements (Lu, Q., E. Kohler, 2009).The relevance of the models, be that as it may, is restricted to different degrees to the circumstances under which the information utilized for preparing the models were collected.There have likewise been a few endeavors to correspond commotion estimations to combination acoustic absorption (ASTM E965-15. 2019) and to foster semi-experimental models to anticipate acoustic retention from combination plan parameters (Lu. Q, 2021, Losa.M, 2013). In view of the writing survey, it is resolved that this review will zero in on the plan and assessment of open-evaluated or permeable black-top blends.

2.2 ROAD TRAFFIC NOISE MODELS

The business related to the assessment of traffic commotion level got energy since specialists began perceiving the effect of natural clamor on general society and underscored to foster guidelines to control the effect. The European Association delivered a progression of orders in such matters, which suggested readiness of commotion maps around significant wellsprings of transportation noises (Gergely, B. European Noise Policy Directive 2002). The most common way of creating instruments to foresee traffic commotion began some time before that. In 1975, Japan distributed its ASJ Model 1975 that could anticipate sound strain level coming from traffic clamor sources. The Government Expressway Organization (FHWA) in the U.S. distributed a report in 1978 that proposed a technique for foreseeing clamor produced by street traffic moving at a steady speed (Barry, T. M., and J. A. Reagan.1978) from that point forward, a few street traffic clamor models and instruments have been created by the legislative organizations all over the planet. A few generally utilized models are summed up as follows.

2.2.1. THE FHWA CLAMOR MODEL (TNM)

In the U.S., the FHWA Traffic Clamor Model (TNM) is expected to be utilized on all parkway projects that get government funding (Hastings, A. L.2019). The TNM applies a few acclimations to a reference commotion level, which is the greatest A weighted sound level transmitted by a vehicle pass by and recorded a ways off of 15 m from the vehicle and a level of 1.5 m over level, by and large absorptive landscape. This reference clamor level, called a vehicle's commotion discharge level (EL), is a component of the vehicle type and speed, motor choke status,roadway incline, and asphalt type. The adjusted noise level is defined by the equation

$$LAeq,1h=ELi +Atraf\ f(i) +Ad +As \quad (1)$$

Where;

LAeq, 1h is the hourly equivalent A-weighted sound pressure level (dBA)

ELi is the vehicle noise emission level for the ith vehicle type

Atraf f (I) is the adjustment of the volume and speed of the ith vehicle type

Ad is the adjustment of the distance between the road and the receiver and for the roadway segment length; and

As is the adjustment for resistive effect between road and receiver (Hastings, A. L.2019).

2.2.2. THE CoRTN MODEL

In the United Kingdom, the CoRTN model was developed to predict road traffic noise (Givargis, S., and M. Mahmoodi. 2008). This model first predicts a reference noise level L0 using Equation (2), which is basic hourly noise level L10 reference distance of 10 m from the nearest roadway, in terms of hourly flow of traffic. A reference traffic speed of 75 km/h is assumed while estimating L0. Then the model also applies a series of changes to predict the hourly A-weighted sound pressure level (LA10, 1h) by equation (3)

$$L0 = 42.2 + 10\log10q \text{ dB (A)} \quad (2)$$

$$LA10, 1h = L0 + \Delta f + \Delta p + \Delta d + \Delta s + \Delta a + \Delta r \quad (3)$$

Where;

q is the hourly traffic flow, and $\Delta f, \Delta p, \Delta d, \Delta s, \Delta a, \Delta r$ are adjustment for traffic flow gradient, pavement type, distance, shielding, angle of view, and reflection, respectively.

2.2.3. THE RLS90 MODEL

In Germany, the RLS90 model is used (Murillo-Gómez, et al. 2015). Using 25m from the center lane as reference distance, it first predicts the A-weighted mean noise level, LmE, as a function of hourly vehicle flow Q and the percentage of heavy vehicle in the traffic stream P, as shown in equation (4) , for a reference condition (i.e. traffic speed is 100km/hr. road gradient is below 5% and the road surface follows a special specification).

$$LmE = 37.3 + 10 \log \{Q (1+0.082)\} \quad (4)$$

Therefore the model applies a series of corrections in the reference noise level by equation

$$Lm = LmE + RSL + RRS + RRF + RE + RDA + RTB. \quad (5)$$

Where;

R SL, RRS, RRF , RE , RDA,RTB, are adjustments for speed limit, road surface types, unevenness of the road surface, absorption by the building surfaces, ground and atmospheric conditions, topography and building dimensions, and distance from the receiver and air absorption, respectively (Quartieri, J., et al. 2009).

2.2.4. THE ASJ RTN MODEL

The ASJ RTN Model used in Japan divides the vehicles in traffic stream in two or four different categories (Fukushima, A., et al.2019).The model estimates the A-weighted noise level of a vehicle by Equation (6).

LWA = a+blog (V) +c. (6)

Where,

LWA is the sound power level (dB),

V is the vehicle speed (km/h),

a and b are relapse/regression coefficients that rely upon the vehicle type and stream condition.

The term "C" records for a progression of remedy factors for any deviation from reference conditions, including road slope, pavement surface type, sound radiation directivity, and any remaining elements.

The model considers a large number of conditions and gives technique to foresee noise level spread if those conditions arise (Yamamoto, K. 2008). The So Street model created in Switzerland has separate formulae for traveler vehicles and trucks to foresee the A-weighted commotion level for a pass-by vehicle (Heutschi, K. SonRoad 2004). Because of EU order on appraisal and the executives of natural commotion, the Harmonoise model was produced for use by part states (Salomons, E., D. et al 2011). This model arranges the vehicles in three classes(light, medium, and weighty vehicle) and considers two point wellsprings of clamor (0.01m and 0.3m over the ground).Each point has explicit sound level comprising of commotion delivered by power train or tire-street friction (Watts, G. et al 2005). The Moving noise is assessed by equation (7).

$$LWR(F) = aR\ (F)+bR(F)\ \log(v/vref). \qquad (7)$$

Where;

Vref is the reference speed of 70km/hr; aR, bR are coefficients in 1/3rd octave bands f is frequency in Hz,

V is vehicle velocity in km/hr.

2.2.5. THE NORD 2000 MODEL

The Nord 2000 model developed for Scandinavian also predicts the noise level by applying a number of adjustment in a reference noise level as shown in equation (8).

$$LR = LW + \Delta Ld + \Delta Lt + \Delta Ls + \Delta Lr \qquad (8)$$

where;

LW is sound power level inside the considered recurrence band and in an accepted reference street
and landscape condition;

ΔLd, ΔLt, ΔLs , ΔLr are amendments for propagating effect of sound divergence, air absorption
effect, terrain type, spread impact of the dissipating zones,and obstacle effect, respectively(Khan, J., et al2021). More subtleties can be tracked down in references (Garg, N., and S. Maji. 2014), (Nielsen, H. L.et al. 1997), and (Bendtsen, H. 1999).

2.2.6 THE NPMB MODEL

The NPMB model was the primary noise expectation strategy presented in France in 1996. Later this model was picked by 11 other European nations. This model gauges the A-weighted sound strain level a ways off from the source and in a specific spread condition, LAC , utilizing Equation(9):

$$LAC = LW - (Adlv + Aatm + Abnd,c). \qquad (9)$$

Where;

LW is sound power level of the source;

Adlv is geometrical spreading;

Aatm is atmospheric absorption;

Abnd,c is the attenuation factor accounting for boundary condition and speed profile.

The specialty of NPMB model is that considering meteorological circumstances was planned, like standard designing models like ISO 96132, it separates the clamor source into rudimentary ones and thinks about a bunch of proliferation ways between the source and the beneficiary at a specific meteorological condition. The drawn out commotion level at the recipient is acquired by the lively summation of clamor level for all likely meteorological circumstances.

References (Garg, N., and S. Maji. 2014), (Dutilleux, G., et al. 2008), (Ece, M. et al . 2018) provide a definite depiction of this model. Aside from the models recorded above, a few different models are also generally utilized in various locales. For example, the Common noise Evaluation Strategies for the EU Part States (CNOSSOS) utilized in Europe, the Traffic Commotion Openness (TRANEX) utilized in the UK, and the Burgess model utilized in Australia are a couple to make reference to. It can be seen that most models follow a comparable way to deal with foresee the vehicle noise level apparent by people in general: first assessing the commotion level under a reference condition, then applying a progression of rectification variables to represent different deviations from It Can be seen that most models follow a similar approach to predict the vehicle noise level perceived by the public: first estimating the noise level under a reference condition, then applying a series of correction factors to account for various deviations from the reference condition. There is also a trend in later or newer versions of the models: they are moving from empirical equations to equations integrating more scientific principles along with application of numerical techniques (Garg, N., and S. Maji. 2014).

It is, however, difficult to delineate the pros and cons of different models since they were calibrated and validated in different regions (Khan, J.,et al. 2021). Variations in the conditions of different regions would lead to site bias in model predictions (Khan, J.,et al. 2021, Oshima, T, et al.2017, Guarnaccia, C.,et al. 2011). This makes the model suitable for only the region it was developed and validated.

2.4 VEHICLE CLASS

There are different class of vehicles using the highway, which are portrayed in the diagram below;

2.4.1. Motorcycles: this are one the major contributors to highway noise pollution. Although they only account for small percentage of traffic, they are much louder than other vehicles due to their small size and higher engine speeds. Research has shown that motorcycles can generate noise levels of up to 110 dB (decibels), which is significantly louder than a car.

2.4.2. Passenger's car: they are not as loud as motorcycles, yet they can still generate noise levels of up to 80 Db. In addition, the number of passenger cars on the road is much higher than the number of motorcycles, so they can have a significant cumulative impact on noise levels.

2.4.3. Truck with four tire single unit: they are also known as semi-trucks, can be a major source of noise pollution on highways. They are louder than passenger's cars, with noise levels of up to 85 db.

2.4.4. Buses: they are not as loud as trucks but they can still produce about 80db, buses often operate at night, and their noise can be particularly disruptive to nearby residence

2.4.5. Trucks with two axle six tire, single unit: the noise generated by this truck is similar to a semi-truck with four tires on a single unit. The main source of noise are the engine, the exhaust, and the tires.

2.4.6. Three axle single unit: this type of truck typically has two axles in the front and one axle in the back. Just like the other types of trucks we've discussed, the main sources of noise are the engine, the exhaust, and the tires. However, the additional axle can also contribute to the noise level, as the additional wheels create more friction with the road surface.

2.4.7. Four or more axle unit: these types of trucks are also known as heavy-duty trucks, typically have two or more trailers. Heavy duty trucks have some unique noise sources. One of these is the trailer itself, which can generate additional aerodynamic drag. Another is the trailer suspension, which can also generate noise. The brakes are much larger in heavy duty trucks than other trucks, they can generate more noise when engaged.

2.4.8. Four or less axle single trailer: these type of trucks are commonly used in the transportation of goods, and they are often referred to as "big rigs" or "18-wheelers." The trailer can act as a soundboard, amplifying the noise from the engine and the exhaust. Lastly the vibration from the trailer can cause noise and wear on truck itself.

2.4.9. Five axle tractor semi-trailer: these is a heavy duty truck commonly used for transportation of goods. These type of truck is typically very loud, due to the large number of noise sources in the engine; the exhaust system, the brakes, the tires, and the trailer all contributribute to the overall noise level.

2.4.10. Six or more axel single trailer: these trucks are even larger than the ones we previously discussed, they are commonly referred to as “mega trucks.” The noise level are way higher than smaller trucks. The longer length of the trailer can cause additional vibration and friction which increases noise.

2.4.11. Five or more axle multi trailers: these types are often referred to as “double trailer trucks” or piggy back trucks”, aside the same noise source earlier discussed. The gap between trailers can cause wind to rush through, creating additional noise.

2.4.12. Six axle multi trailers: these are the largest trucks on the road they are also called “jumbo trucks” or “B-trains”. In addition to the common noise source for vehicles, the multi trailers can generated from additional friction between the trailers and their complex suspensions.

2.4.13. Seven or more axle multi trailers: they are sometimes called “super jumbo trucks”, they are the largest vehicle on the road. Apart from the other sources of noise produced by trucks, they also have a unique sound caused by the multi trailers. This sound known as “swish,” is created by the movement of trailer through the air which is noticeable at higher speed.

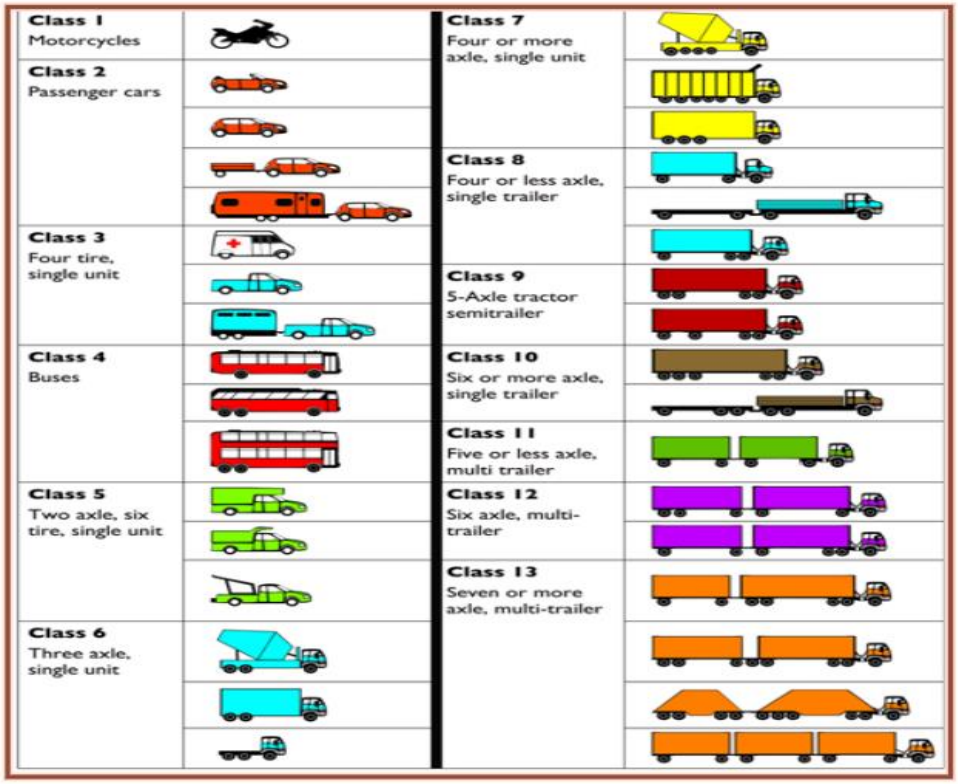


Fig 2.1 vehicle class

Source: office of highway policy information

2.5 PAVEMENT SURFACES

For this research we will be considering three types of pavement which include;

2.5.1 FLEXIBLE PAVEMENT

This type of pavement is made of asphalt Flexible pavement refers to a type of road construction that is designed to withstand heavy traffic loads while providing a smooth and comfortable driving surface. It is commonly used in highway and road construction due to its cost-effectiveness, durability, and ability to adapt to changing conditions. In this discussion, we will explore the key components and construction process of flexible pavement, as well as its advantages and disadvantages.

COMPONENTS OF FLEXIBLE PAVEMENT

I. SUB-GRADE: The subgrade is the natural soil or compacted fill material on which the pavement is constructed, it is the layer of the soil or rock beneath the pavement structure. It provide support for the pavement and transfers the loads support imposed by traffic to the underlying soil or rock. The subgrade should have adequate bearing capacity, strength, and stability to ensure proper performance and durability of the pavement. The quality of the subgrade can affect the design and performance of the pavement. A poor quality subgrade can lead to premature failure of the pavement due to settlements, cracking, and rutting. To improve the quality of the subgrade, various techniques such as compaction, and stabilization.

II. SUB-BASE: The sub-base layer is placed above the subgrade and consists of granular materials like crushed stones or gravel. It helps in distributing the load from the traffic and provides additional support to the pavement structure, the sub base also provide drainage, prevents moisture from reaching the subgrade. The sub base is typically composed of crushed stone or recycled concrete, and should be compacted to provide a stable foundation. Its functions are as follows;

for support, to improve drainage, for stress absorption and to improve pavement performance.

iii. Base Course: The base course is located above the sub base and is typically made of high-quality aggregates like crushed stones or asphalt concrete. It acts as a load-spreading layer and enhances the structural strength of the pavement. Materials commonly used for base courses in flexible pavements include crushed stone, gravel, sand, stabilized soil, or recycled materials. The selection of this materials is based on factors such as strength, durability, availability, and cost- effectiveness

iv. Surface Course: The surface course is the topmost layer of the pavement and is designed to provide a smooth and skid-resistant driving surface. It is usually composed of asphalt concrete, which is a mixture of asphalt binder and aggregates.it is also known as the wearing course or surfacing, it's the top layer of the pavement that comes into direct contact with traffic. It is designed to prevent skidding in wet or slippery conditions. Materials commonly used for surface courses in flexible pavement include asphalt concrete (hot mix asphalt), bituminous concrete, or other types of specialized surface treatments. The selection of materials is based on factors such as traffic volume, climate conditions, desired performance characteristics, and project budget. Proper design, construction, and maintenance of the surface course are essential to ensuring the long-term performance, safety, and aesthetics of flexible pavement system. Regular inspection and maintenance activities, such as crack sealing, pothole repair, and surface rejuvenation, help extend the service life of the surface course and the overall pavement structures.

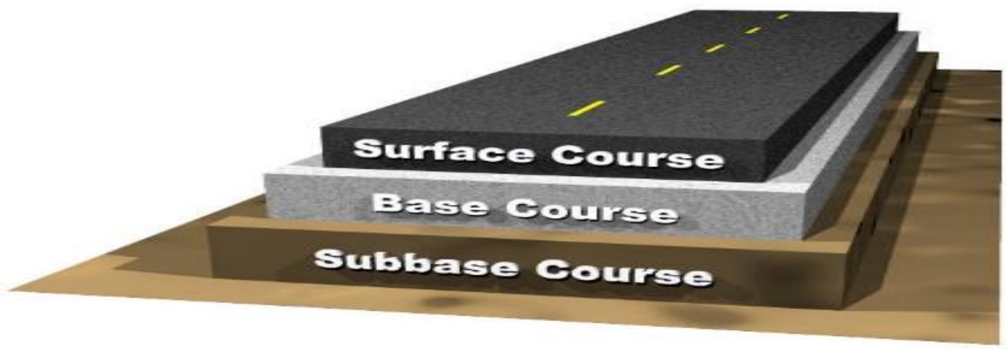


Fig 2.2: flexible pavement

Source: Federal Highway Administration (FHWA)

2.5.2 RIGID PAVEMENT

This pavement is also known as concrete pavement, is a type of road construction that utilizes a rigid layer of concrete to provide a durable and long-lasting driving surface. In this discussion, we will explore the key components and construction process of rigid pavement, as well as its advantages and disadvantages, with references for further exploration.

COMPONENTS OF RIGID PAVEMENT

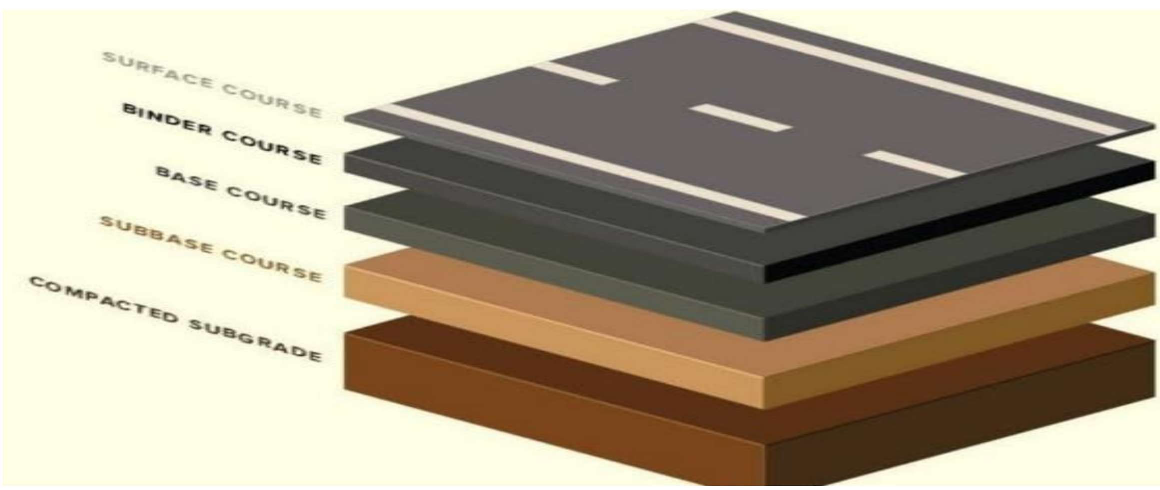
1. Subgrade: The subgrade is the natural soil or compacted fill material on which the pavement is constructed. It provides the foundation for the rigid pavement structure, and plays a crucial role in providing support, stability and load distribution to the pavement structure. The subgrade distribute the loads from the rigid pavement slab to a larger area of the underlying soil, reducing the pressure and stresses applied to the subgrade and minimizing the risk of failure or deformation. Common techniques used to improve the subgrade in rigid pavement construction include, moisture control, subgrade stabilization with additives like lime or cement, and the use of geotextiles or to enhance the subgrade’s strength and stability.

2. Base Course: The base course is placed above the subgrade and serves as a load-spreading layer. It can be made of granular materials like crushed stones or lean concrete, it is located above the subgrade and beneath the concrete slab. The base course in a rigid pavement system provides additional support, load distribution, and stability to the pavement structure, helping to enhance its overall performance and longevity.

3. Sub-base Course: In some cases, a sub-base layer is added between the base course and the subgrade to enhance the pavement's load-bearing capacity. It can consist of materials like stabilized soil or aggregate base. Proper design and

construction, and compaction of the sub base layer are essential to the successful performance and longevity of a rigid pavement system. Materials commonly used for sub base layer in rigid pavement construction include graded aggregate base course materials, recycled concrete aggregate, stabilized soil, or other suitable materials with good strength and drainage properties.

4. Concrete Slab: The concrete slab is the main structural component of rigid pavement. It is typically made of Portland cement concrete, reinforced with steel bars or fibers, and designed to withstand traffic loads. Design considerations for concrete slabs in rigid pavements include factors such as slab thickness, reinforcement, joint spacing, surface texture, and mix design. Proper construction practices, including proper curing, finishing, and joint sealing, are essential to ensure the quality and performance of the concrete slab.



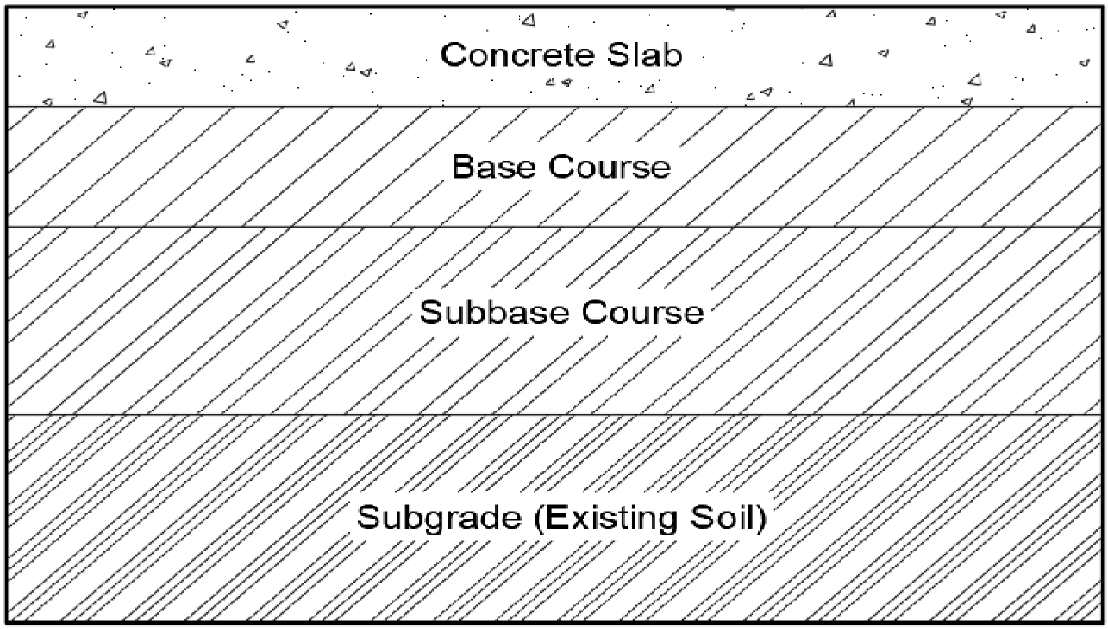


Fig 2.3&2.4: Rigid pavement

Source: Federal Highway Administration (FHWA)

2.5.3. COMPOSITE PAVEMENT

Composite pavement refers to a type of pavement structure that involves combining different materials to create a durable and cost-effective road surface. Typically, composite pavement systems consist of multiple layers of various materials, each serving a specific purpose to enhance the overall performance of the pavement.

The most common type of composite pavement involves combining asphalt concrete (AC) layers with Portland cement concrete (PCC) layers. The AC layers provide flexibility and resistance to fatigue, while the PCC layers offer strength and durability. By combining these two materials in a layered structure, composite pavements can take advantage of the beneficial properties of each material.

Composite pavements are often used in areas where heavy traffic loads or challenging environmental conditions require a pavement structure that can withstand significant stresses. The combination of materials allows for a more customized pavement design that can optimize performance and longevity.

Fig 2.5: composite pavement

Source: Federal Highway Administration (FHWA)

2.6 FIELD MEASUREMENTS

2.6.1 NOISE LEVEL METER:

Fig2.5: Noise level meter

Source: google.com

This is a diagrammatical representation of a noise level meter. The working mechanism of a sound level meter is based on the principles of acoustics and electronics. The basic components of a sound level meter include a microphone, a preamplifier, a measuring amplifier, and a display unit. The microphone converts sound waves into electrical signals, which are then amplified by the preamplifier and measuring amplifier. The amplified signal is then converted into a decibel reading on the display unit. The decibel scale is logarithmic, which means to continue with the working mechanism of the sound level meter, we need to understand the concept of "sound pressure level." Sound pressure level (SPL) is a measure of the intensity of sound, and is expressed in decibels (dB). The higher the SPL, the louder the sound. The SPL is measured by the sound level meter and is displayed on the meter's display unit. The SPL can be used to determine the noise level in a given environment and to assess whether the noise level is within acceptable limits. Sound level meters are used in a variety of applications, including industrial noise monitoring, environmental noise measurement,

There are two main types of sound level meters: integrating meters and peak meters. Integrating meters provide an average reading of the sound level over a period of time, while peak meters provide a reading of the maximum sound level that was measured. Both types of meters have their advantages and disadvantages. Integrating meters are useful for measuring average noise levels, but they are not good at measuring brief, high-intensity sounds. Peak meters are good at measuring brief, high-intensity sounds, but they can be more difficult to interpret.

Sound level meters can also be classified based on their response time.

2.6.2 NOISE MONITORING STATION.

Fig2.7: Noise monitoring station.

Source: google.com

A noise monitoring station is a system that measures and analyzes sound levels in the environment. It consists of a number of sensors, a data acquisition system, and a computer that processes the data and displays it in a user-friendly format. The sensors are typically placed at specific locations, such as near highways or airports, to measure the sound levels in those areas. The data acquisition system collects and stores the data from the sensors. The computer processes the data and generates reports that can be used to analyze the noise levels and make decisions about how to mitigate the noise. The data collected by the noise monitoring station can be used in explaining the working principle of a noise monitoring station, let's take a look at the different types of sensors that can be used in such a system. The most common type of sensor is the microphone, which converts sound waves into electrical signals. Other types of sensors that can be used include vibration sensors, which measure vibrations in the ground or air, and infrared sensors, which detect infrared light emitted by sources of noise. All of these sensors produce electrical signals that are sent to the data acquisition system for processing.

There are a number of ways to analyze the data from a noise monitoring station. One common method is called "contour mapping," which involves creating a map that shows the noise levels at different locations. This can be useful for identifying problem areas and planning mitigation measures. Another analysis method is called "time-frequency analysis," which looks at how the sound levels vary over time. This can be used to identify patterns in the noise levels and determine the source of the noise. There are many other analysis methods that can be used to analyze the data from a noise monitoring station. The results of the analysis can be used to make decisions about how There are a number of ways that the results of a noise monitoring analysis can be used. One common application is to design noise mitigation measures. For example, if the analysis reveals that a certain location is experiencing high noise levels, the government or a business may decide to implement measures to reduce the noise, such as erecting noise barriers or using sound-absorbing materials. The results of the analysis can also be used to evaluate the effectiveness of existing noise mitigation measures. In addition, the data can be used for research purposes, such as studying the effects of noise on human health or the environment

2.7 PREVIOUS WORK DONE ON THIS STUDY

Researchers like (Sun et al. 2018) conducted laboratory experiments to measure the sound absorption coefficient of different asphalt mixtures. They found that the use of open-graded asphalt mixtures significantly improved sound absorption compared to dense-graded mixtures.

In a study by (Al-Mansour and Hanna 2019), the acoustic properties of concrete pavements were evaluated. They concluded that the surface texture of the concrete, such as the use of exposed aggregate or broom finishing, significantly influenced noise levels. Rubberized asphalt has also been extensively studied for its noise-reducing properties. For instance, (Cai et al. (2020) investigated the sound absorption and noise-reducing performance of rubberized asphalt mixtures. Their findings indicated that rubberized asphalt had superior noise reduction capabilities compared to conventional asphalt mixtures.

In a Study by (Li et al. 2017) Li et al. conducted a study to compare the impact of flexible (asphalt) and rigid (concrete) pavements on highway noise pollution. The researchers collected noise measurements from several highways with different pavement types and analyzed the data using statistical methods. The results showed that rigid pavements generally produced higher noise levels compared to flexible pavements. The differences in noise levels were attributed to the differences in surface texture, tire-pavement interaction, and sound reflection properties of the two pavement types.

Research by (Zhang et al. 2019): Zhang et al. investigated the impact of pavement types on tire-pavement noise generation. The study involved measuring tire-pavement noise under controlled laboratory conditions using a tire-pavement noise test system. The researchers compared the noise generated by tires rolling on flexible and rigid pavements with varying surface textures. The findings indicated that flexible pavements with certain surface textures, such as open-graded asphalt mixtures, exhibited lower tire-pavement noise levels compared to rigid pavements. The study emphasized the importance of surface texture in reducing tire-pavement noise.

Work by (Cebon et al. 2018): Cebon et al. conducted a comprehensive review of studies comparing the acoustic properties of flexible and rigid pavements. The review encompassed research from various countries and highlighted the impact of pavement type, surface texture, and vehicle speed on noise generation and propagation. The findings suggested that flexible pavements generally provide better noise reduction compared to rigid pavements due to their ability to absorb and dissipate acoustic energy. However, the review also emphasized the importance of considering other factors such as traffic characteristics, environmental conditions, and pavement condition in assessing noise pollution.

Study by (Vos et al. 2020): Vos et al. conducted a field study to evaluate the impact of pavement type on noise levels in urban areas. The researchers compared the noise levels generated by vehicles traveling on flexible and rigid pavements in residential neighborhoods. The findings indicated that flexible pavements, particularly those with porous asphalt surfaces, resulted in lower noise levels compared to rigid pavements. The study highlighted the potential of porous asphalt pavements in reducing noise pollution in urban environments.

Research by (Zhao et al. 2018): Zhao et al. investigated the effects of different pavement types on tire-pavement noise and rolling resistance. The study involved conducting laboratory tests using a rolling resistance and noise testing machine. The researchers compared the noise levels and rolling resistance of tires on flexible and rigid pavements with different surface textures. The results showed that flexible pavements, particularly those with certain surface textures, exhibited lower noise levels and rolling resistance, indicating their potential for noise reduction and improved energy efficiency.

Work by (European Commission 2019): The European Commission published a report summarizing the findings of various studies on the impact of pavement type on road traffic noise. The report highlighted that while both flexible and rigid pavements can contribute to noise reduction, flexible pavements generally offer better noise mitigation due to their ability to absorb sound energy. The report emphasized the importance of considering the whole life cycle cost, durability, and safety aspects when selecting pavement types for noise reduction purposes.

Study by (Liang et al. 2020): Liang et al. conducted a study to assess the impact of different pavement types on traffic noise in urban areas. The researchers collected noise data from various road sections with flexible and rigid pavements and analyzed the measurements using statistical methods. The findings indicated that flexible pavements, especially those with certain surface textures and materials, exhibited lower noise levels compared to rigid pavements. The study emphasized the importance of considering pavement characteristics, such as surface texture and composition, in mitigating traffic noise.

Research by (Dantas et al. 2019): Dantas et al. investigated the influence of pavement type on traffic noise levels in a Brazilian urban area. The study involved measuring noise levels from vehicles traveling on different road sections with flexible and rigid pavements. The findings revealed that flexible pavements with certain characteristics, such as rubberized asphalt, demonstrated better noise reduction capabilities compared to rigid pavements. The research highlighted the potential of using specific pavement types to mitigate traffic noise in urban environments.

Work by (Abdullah et al. 2018): Abdullah et al. conducted a study to evaluate the impact of pavement type on traffic noise using a simulation approach. The researchers developed a noise prediction model that incorporated parameters such as pavement type, surface texture, and traffic characteristics. The simulations showed that flexible pavements, particularly those with porous asphalt surfaces, resulted in lower noise levels compared to rigid pavements. The study emphasized the importance of considering pavement characteristics in noise prediction models for effective noise mitigation planning.

Study by (Hossain et al. 2017): Hossain et al. investigated the impact of pavement type on noise levels in a residential area near a highway. The researchers collected noise measurements from different locations near the road, comparing sections with flexible and rigid pavements. The findings indicated that flexible pavements, particularly those with certain surface textures and thicknesses, resulted in lower noise levels compared to rigid pavements. The study highlighted the potential of using specific pavement types and designs to mitigate noise pollution in residential areas.

Overall, the literature review suggests that flexible pavements, especially those with specific characteristics such as porous asphalt or rubberized asphalt surfaces, generally exhibit lesser noise reduction capabilities compared to rigid pavements. The surface texture, composition, and thickness of the pavement are critical factors influencing the generation and propagation of traffic noise. However, it is important to consider other factors such as traffic characteristics, environmental conditions, and pavement condition when evaluating the impact of pavement types on highway noise pollution. Further research and field studies are needed to explore the long-term performance and cost-effectiveness of different pavement types in mitigating noise pollution.

A sound level meter, also known as a decibel meter, is a device used to measure the intensity of sound in a given environment.

2.8 NOISE REDUCTION TECHNIQUES

The literature review also encompasses studies that have explored various noise reduction techniques through the use of different pavement materials. (Zhang et al. 2019) studied the impact of porous pavements on noise pollution. They observed that porous asphalt and concrete pavements exhibited considerable noise reduction due to their ability to dissipate sound energy through their porous structure.

Another approach to reducing noise pollution is the use of innovative materials, such as recycled materials or additives. For example, (Wang et al. 2017) investigated the impact of incorporating crumb rubber and recycled concrete aggregates into asphalt mixtures. Their study showed that these materials improved sound absorption and reduced noise levels on highways.Several field studies and case studies have been conducted to assess the real-world performance of different pavement materials in reducing highway noise pollution.

In a field study by (Li et al. 2021), the noise reduction performance of various pavement types, including asphalt, concrete, and rubberized asphalt, was evaluated. The results indicated that rubberized asphalt demonstrated the highest noise reduction, followed by porous asphalt, while conventional asphalt had the least noise reduction effect. Similarly, a case study conducted by (Tidblad et al. 2018) examined the impact of different pavement materials on noise levels in urban areas. They found that the use of porous pavements and noise-reducing asphalt significantly reduced noise pollution and improved the acoustic environment

The literature review highlights that the selection of pavement materials plays a crucial role in mitigating highway noise pollution. Studies have demonstrated that materials such as open-graded asphalt, rubberized asphalt, and porous pavements exhibit superior noise-reducing properties compared to conventional materials.

CHAPTER THREE

3.0. METHODOLOGY

3.1. STUDY AREA

The three areas to be studied are: the Lagos- Benin road, from ekosodin junction (6^0 24’09’’N 5^0 36’30’’E to 6^0 24’09’’N 5^0 35’35’’E) according to fig 3.1.1 of a distance of 626m towards the main gate of the great university of Benin, this particular highway has a flexible pavement. This pavement is always busy due to its closeness to the university where various activities are carried out, aside that it happens to be a federal road which means it support inter-state travels.

Fig 3.1.1 Ekosodin junction

The second area of study which is the rigid pavement is located at uselu which is along lagos-benin road (from 6^{0}22’01’’N 5037’01’E to 6^{0}24’07’’N 5^{0}36’31’’E) with a distance of 631m towards the traditional ground, this particular road is lso a federal road. It was constructed as a rigid pavement so that it can withstand the erosive effect of the area due to flood and in return have the capacity to withstand any class of vehicle that will be using it.

Fig 3.1.2 Uselu park

The third location is along sapkonba road, its pavement is a composite pavement located at (6^0 22’01’’N 5^0 37’01’E to 6^0 22’01’’N 5^0 37’10’E) the entire road is 183m. This area is a street which is not always busy.

Fig 3.1.3 igun street sapkonba

Source: Google earth

80m from ($6^0$19’55’’N $5^0$37’30’’E)

3.2 DATA SOURCES

The major source of information was noise measurements made with a digital sound level meter and expressed in decibels. Secondary data from journals, official publications, seminars, and workshop papers were used in the research. To compare the sound level data obtained using the sound level meter with acceptable noise level criteria, sources were consulted.

The table below shows the World Health Organization guideline for community noise from different noise sources and their permissible limits for healthy living.

TABLE 3.0 WHO guideline for community noise (World Health Organization, 1995)

Environment	Critical Health Effect	Sound level dB(A)	Time (hours)
Outdoor living area	Annoyance	50-55	16
Indoor dwellings	Speech Intelligibility	35	16
Bedroom	Sleep disturbance	30	8
School classrooms	Disturbance of Communication	35	During class
Industrial, commercial and traffic areas	Hearing impairment	70	24
Music through earphones	Hearing impairment	85	1
Ceremonies and Entertainment	Hearing impairment	100	4

3.3 DATA COLLECTION

To have a visual understanding of the landscape around Benin City, a reconnaissance survey was initially conducted. In order to decide which of the many potential routes or monitoring locations may be worthy of a complete assessment, a quick but thorough examination of the research region is conducted. The reconnaissance survey helps to identify the more promising routes or places having the following pavements to be studied. Three (3) different noise monitoring sites were chosen to accurately depict the study area's heavy traffic noise pollution areas. In order to compare reported noise levels with acceptable criteria, noise levels were monitored at these locations.

3.3.1 INSTRUMENTAL SURVEY

Using the sound level meter, noise data was gathered at the sampling locations. (SLM, Super Scientific Model 840029. The decibels used for noise measurements on the A-weighted scale [dB(A)] represent and resemble the human hearing range between 50 and 100 Db. About 1.5 meters above ground level, the instrument is held in front of the noise source while being parallel to the ground. GPS was used to gather the sampling sites' coordinates. For a week, noise levels at each sampling site were monitored between (2-4pm), when traffic was at its busiest. The microphone was directed at the alleged noise source at a distance of not less than 1 m from any reflective object, and the instrument was held comfortably in the hand.

3.3.2 DATE AND TIME:

Data was gathered for a week between Monday, February 25th, and Sunday, march 3rd, 2024, during the peak hour of 2:00 pm to 4:00 pm daily at the chosen location. The number of hours corresponds to the daily peak times. It could be argued that the frequent occurrence is caused by the fact that employees and students around the environ leave their homes between the hours of 8 and 10 in the morning, and that a similar pattern also appears between the hours of 2-4 in the afternoon when they return home after working all day. (Nwankwo et. Al 2019).

3.3.3 MEASURING EQUIPMENT

Digital sound meter is the instrument for measurement; this instrument using a SPER Scientific 840029 digital sound meter. This variant is ideal for testing in accordance with OSHA regulations. Meets the frequency and temporal weighting requirements for a Type 2 sound meter set out in IEC 61672:2013 and ANSI S1.4:2014. It offers a wide range of measurement settings, such as peak function, AC or DC output, A and C decibel frequency weighting scales, a frequency range of 31.5 to 8000Hz, fast reaction with a maximum value readout at 0.2 seconds or slow response with a maximum value readout at 1.5 seconds. A low battery and an over or under loaded device are also indicated on the big display, which has a resolution of 0.1db. The meter also covers 30 to 130db in the A scale and 35 to 130dB in the C scale, with an accuracy of + or -1.0db. It can be easily calibrated using the internal oscillation system and also has a fold out stand and comes with carrying case, instructions, calibration tool, windscreen, and a 9v battery. N.I.ST. Traceable certificate of calibration available.

3.3.4 DATA ANALYSIS

The data was analyzed and presented using frequency distribution tables, charts, figures and percentage to show if the research objectives have been met. The statistical tool used for the analysis of this research is the Arithmetic Mean.

Calculating an arithmetic mean involves adding together numerous numbers and dividing the total by the number of numbers. In this study, the standard noise level for traffic zones was computed together with the mean noise value.

Mean noise level;

$$(LAeq) = \frac{\sum \text{LAeq}}{n} \quad (3.1)$$

Where:

LAeq = Equivalent A-weighted noise pressure level

n = number of noise measurements

Fig 3.4: Sound level meter

CHAPTER FOUR

4.0. RESULTS AND DISCUSSION

Data must first be interpreted and presented in a way that will make it engaging to the user for decision making purposes, else it won't be valuable in its raw, unprocessed, and unanalyzed state. This chapter discusses the statistical analysis performed using the sound level meter noise data. Simple statistical methods like frequency counts and percentages were employed both objectively and qualitatively (Tables and Charts) for the sake of being clear.

Noise Measurement Locations

Three (3) different noise monitoring sites were chosen to accurately depict the study of the different pavement and their noise pollution. Using GIS, the monitoring stations were geo-referenced..

TABLE 4.1 sampling locations

ID	Pavement type	Coordinate	Distance	Description
A1	Flexible	6^0 24'09''N 5^0 36'30''E to 6^0 24'09''N 5^0 35'35''E	626 m	Ekosodin junction
A2	Rigid	6^0 22'01''N 5^0 37'01'E to 6^0 22'01''N 5^0 37'10'E	183 m	Uselu park
A3	Composite	6^0 19'54''N 5^0 37'29''E to 6^0 19'54'‘N 5^0 37‘29‘'30E	87 m	Igun street

4.1 NOISE MEASUREMENT RESULT

The noise values gotten from each of the sampling locations using the sound Level meter is shown below.

Table 4.2. Result from Day 1

Pavement type	Vehicle class	Readings in decibels				
		1st	2nd	3rd	4th	5th
Flexible	Class1	84.0	76.0	70.0	78.0	80.0
	Class2	86.1	85.8	85.7	85.9	85.7
	Class3	71.4	71.5	71.2	70.8	71.4
	Class4	74.7	74.9	75.0	75.2	75.3
	Class5	86.5	86.6	86.4	86.5	86.4
	Class6	93.4	93.4	93.3	93.5	93.4
	Cass 7	82.4	82.3	82.3	82.5	82.4
	Class 8	84.3	84.2	84.2	84.4	84.3
Rigid	Class1	70.8	71.5	71.0	70.9	71.8
	Class2	96.2	96.4	96.0	96.8	97.1
	Class3	89.5	88.8	89.9	89.1	91.2
	Class4	88.0	87.8	88.6	88.7	87.9
	Class5	87.0	86.5	87.7	88.0	87.3
	Class6	88.8	89.6	89.3	89.1	89.0
	Cass 7	88.9	89.5	89.7	89.0	88.9
	Class 8	87.6	87.9	88.7	88.4	87.4
Composite	Class1	77.0	76.8	76.7	76.9	76.1
	Class2	68.4	70.5	69.3	68.3	72.5
	Class3	64.0	62.9	63.0	63.4	64.2
	Class4	57.9	57.8	58.0	58.9	58.9
	Class5	65.8	66.9	66.0	66.3	67.0
	Class6	80.2	79.9	81.0	80.7	79.7
	Cass 7	80.5	81.2	80.9	81.0	80.4

	Class 8	86.3	86.9	87.0	87.7	88.6

Table 4.3 Result from Day 2

Pavement type	Vehicle class	Readings decibels				
		1st	2nd	3rd	4th	5th
Flexible	Class1	74.8	74.4	75.4	75.5	74.9
	Class2	87.9	87.5	88.4	88.3	87.9
	Class3	79.5	79.5	80.8	81.9	80.8
	Class4	78.4	78.9	77.7	77.9	78.1
	Class5	88.8	89.5	88.3	89.9	89.5
	Class6	90.5	89.8	90.8	90.9	90.5
	Class 7	88.6	87.8	88.9	87.6	89.6
	Class 8	88.9	88.6	87.8	89.6	87.6
Rigid	Class1	83.7	84.9	83.3	84.8	84.8
	Class2	73.7	73.9	72.9	72.0	73.5
	Class3	87.5	87.8	87.3	87.6	87.8
	Class4	84.9	84.6	84.8	83.3	84.9
	Class5	82.8	83.6	84.0	82.9	83.7
	Class6	87.8	88.9	88.5	88.0	88.3
	Cass 7	92.8	93.6	93.9	94.3	94.4
	Class 8	89.8	90.5	90.6	90.5	90.1
Composite	Class1	77.0	76.5	78.3	78.3	78.4
	Class2	74.3	75.9	75.3	74.8	74.7
	Class3	66.8	67.5	67.4	67.9	66.4
	Class4	57.4	57.8	58.2	58.0	57.6
	Class5	65.8	65.9	65.5	65.8	65.5
	Class6	76.3	75.9	75.0	75.0	75.8
	Cass 7	87.0	87.0	87.4	87.8	87.3
	Class 8	94.5	94.2	94.9	93.9	94.0

Table 4.4 Result from Day 3

Pavement type	Vehicle class	Readings decibels				
		1st	2nd	3rd	4th	5th
Flexible	Class1	77.6	77.8	78.6	78.5	78.0
	Class2	90.2	90.6	89.0	89.5	88.2
	Class3	69.8	69.3	69.4	70.0	68.0
	Class4	79.6	79.4	80.7	81.0	79.8
	Class5	88.0	88.6	89.0	90.6	87.8
	Class6	92.4	93.5	93.7	94.0	92.4
	Cass 7	86.5	86.8	87.4	87.0	87.3
	Class 8	88.0	89.7	89.7	89.8	89.3
Rigid	Class1	77.7	77.9	78.5	77.3	77.6
	Class2	74.5	73.8	73.9	74.7	74.1
	Class3	89.9	88.7	89.5	88.0	88.9
	Class4	89.5	89.9	91.0	90.6	91.0
	Class5	86.5	87.7	87.2	88.0	87.2
	Class6	92.8	93.6	93.7	93.8	93.1
	Cass 7	92.9	91.9	93.0	92.0	93.2
	Class 8	92.0	91.8	92.6	92.2	92.4
Composite	Class1	75.8	74.9	75.5	76.0	75.8
	Class2	70.8	71.5	70.5	70.9	71.3
	Class3	68.9	68.4	69.0	68.6	69.1
	Class4	62.6	63.8	63.0	63.9	63.2
	Class5	70.8	70.9	70.5	69.8	70.0
	Class6	78.8	78.4	79.0	78.3	79.5
	Cass 7	79.9	78.8	79.6	80.4	79.3
	Class 8	78.4	79.0	80.7	80.6	78.8

Table 4.5 Results from Day 4

Pavement type	Vehicl e class	Readings in decibels				
		1st	2^{nd}	3rd	4th	5th
Flexible	Class1	72.0	71.9	72.0	72.7	72.4
	Class2	88.7	87.8	885	89.0	88.5
	Class3	78.8	79.5	79.0	78.9	78.8
	Class4	77.9	77.3	77.9	78.0	77.4
	Class5	98.6	100.8	99.9	99.2	99.0
	Class6	94.5	93.8	94.4	94.1	93.2
	Cass 7	90.3	90.0	89.7	89.6	89.9
	Class 8	88.0	87.5	87.7	88.5	87.8
Rigid	Class1	78.8	79.4	78.6	79.8	79.9
	Class2	78.7	77.8	78.4	79.0	78.6
	Class3	81.9	83.0	82.3	83.5	83.3
	Class4	92.9	93.6	93.3	93.8	92.4
	Class5	88.0	88.5	87.8	88.9	87.8
	Class6	94.9	92.8	93.8	94.0	94.0
	Cass 7	90.5	89.4	89.9	90.8	90.9
	Class 8	89.7	90.3	90.5	90.0	90.0
Composite	Class 1	79.5	80.5	80.3	79.5	79.2
	Class2	73.8	74.0	74.6	73.9	74.7
	Class3	68.9	68.8	69.9	70.0	69.9
	Class4	59.8	60.5	59.9	60.8	60.0
	Class5	71.9	72.4	72.0	72.9	72.3
	Class6	75.8	74.9	75.0	75.9	75.4
	Cass 7	75.8	75.6	76.0	75.2	75.9
	Class 8	87.0	86.8	87.5	86.0	87.2

Table 4.6 Results from Day 5

Pavement type	Vehicle class	Reading in decibels				
		1^{st}	2nd	3rd	4th	5th
Flexible	Class1	75.7	75.2	74.6	75/0	74/5
	Class2	89.4	88.3	88.7	89.5	89.1

	Class3	76.3	76.9	77.1	76.9	76.8
	Class4	89.7	90.1	89.0	90.3	90.4
	Class5	82.8	83.9	83.8	83.0	83.5
	Class6	95.0	95.2	94.5	94.8	95.0
	Cass 7	85.8	86.0	84.9	85.0	85.8
	Class 8	90.6	90.4	89.5	90.0	90.0
Rigid	Class1	87.9	87.0	87.3	87.8	87.0
	Class2	90.0	90.9	89.5	89.8	90.8
	Class3	84.0	84.9	84.6	85.0	84.5
	Class4	85.9	85.3	85.8	85.0	85.5
	Class5	90.8	90.5	89.9	90.0	91.3
	Class6	87.8	87.9	87.3	88.0	88.0
	Cass 7	94.7	95.7	94.9	95.0	95.7
	Class 8	93.8	93.5	92.4	92.9	93.4
Composite	Class1	69.0	70.9	70.0	69.9	70.2
	Class2	73.5	72.2	73.8	72.0	73/0
	Class3	65.8	66.9	67.0	67.3	66.0
	Class4	59.9	60.0	59.0	59.7	60.4
	Class5	69.0	69.2	70.0	69.9	70.4
	Class6	78.9	79.9	79.4	80.0	79.8
	Cass 7	88.8	89.6	89.0	89.3	89.3
	Class 8	90.9	90.8	90.9	90.8	90.1

Table 4.7 Results from Day 6

Pavement type	Vehicle class	Reading in decibels				
		1st	2nd	3rd	4th	5th
Flexible	Class1	78.5	77.9	77.8	76.9	78.4
	Class2	86.0	86.2	86.5	86.2	86.1
	Class3	76.3	76.9	76.8	77.0	76.8
	Class4	79.5	79.9	79.3	78.2	79.6
	Class5	90.0	89.4	90.5	89.9	89.7
	Class6	98.7	98.0	97.9	97.7	98.7
	Cass 7	86.6	86.9	87.8	87.4	86.3
	Class 8	85.5	85.9	86.8	86.2	86.6
Rigid	Class1	79.9	80.7	80.6	80.1	80.2
	Class 2	88.0	88.7	87.7	87.9	87.7

	Class3	88.8	88.6	89.0	89.2	89.4
	Class4	87.2	87.3	87.5	87.8	87.2
	Class5	93.0	93.3	93.5	93.0	93.2
	Class6	91.5	91.5	89.5	90.9	91.6
	Cass 7	94.9	94.8	94.0	94.1	94.7
	Class 8	90.0	89.4	90.5	89.9	89.7
Composite	Class1	80.6	80.5	80.0	80.9	80.0
	Class2	70.6	69.7	69.9	70.7	70.6
	Class3	68.0	69.9	69.0	68.9	69.2
	Class4	60.0	60.7	61.0	60.5	60.8
	Class5	69.0	70.9	70.0	69.9	70.2
	Class6	79.5	81.4	81.0	80.4	80.7
	Cass 7	80.9	81.1	81.5	81.4	80.6
	Class 8	88.8	88.6	89.0	89.4	88.7

Table 4.8 Results from Day 7

Pavement type	Vehicle class	Readings in decibels				
		1st	2nd	3rd	4th	5th
Flexible	Class1	83.3	83.1	83.9	82.9	83.8
	Class2	85.2	85.9	85.7	85.0	85.7
	Class3	80.6	79.9	79.8	80.9	79.8
	Class4	83.6	83.1	83.9	83.0	82.9
	Class5	98.0	98.7	98.0	98.6	98.2
	Class6	95.2	95.5	95.9	96.4	96.5
	Cass 7	90.5	90.6	90.9	91.4	90.6
	Class 8	75.8	75.8	75.0	76.2	75.7
Rigid	Class1	82.7	83.0	83.7	82.8	83.8
	Class2	85.9	85.3	85.8	85.0	85.5
	Class3	86.0	86.2	86.5	86.2	86.1
	Class4	85.9	85.5	85.9	85.1	85.6
	Class5	91.0	90.4	90.9	90.1	90.6
	Class6	86.4	86.8	86.9	86.0	86.9
	Cass 7	95.1	95.3	95.5	95.0	95.1
	Class 8	93.0	93.6	93.2	93.7	93.0
Composite	Class1	84.4	84.9	83.7	83.9	85.1
	Class2	70.0	70.7	71.0	70.9	71.4
	Class3	64.9	64.4	63.7	63.9	65.1
	Class4	59.6	60.3	59.7	60.6	59.8
	Class5	71.0	71.6	71.1	70.9	71.9
	Class6	81.2	81.4	81.8	81.7	80.9
	Cass 7	80.7	80.0	79.9	81.0	79.9
	Class 8	96.7	96.0	97.0	97.0	97.3

From the noise data shown in Table 4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.5, 4.2.6 & 4.2.7 the average daily noise levels was gotten. This is shown in Table 4.3

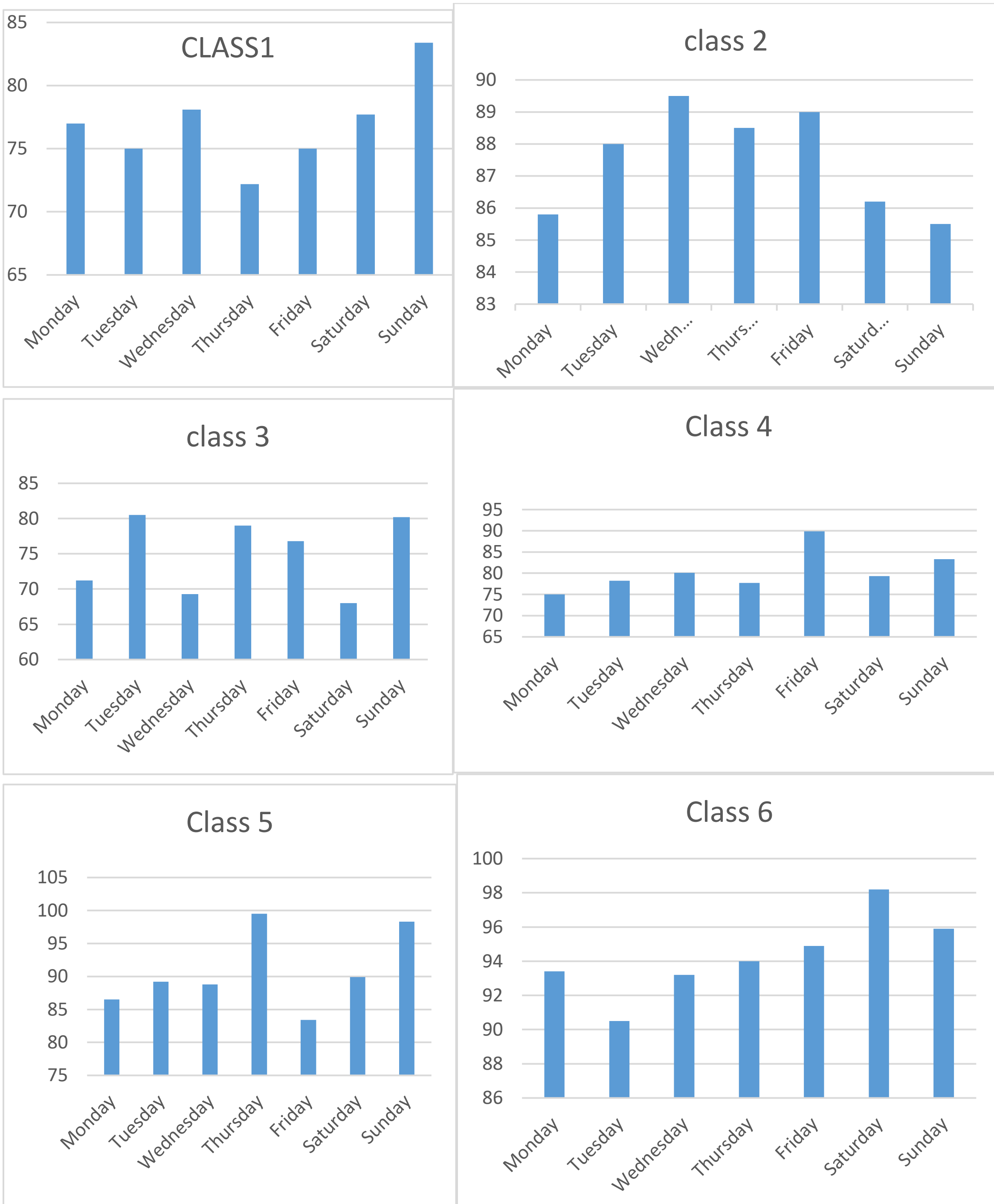
Table 4.9 Average daily noise level in decibels

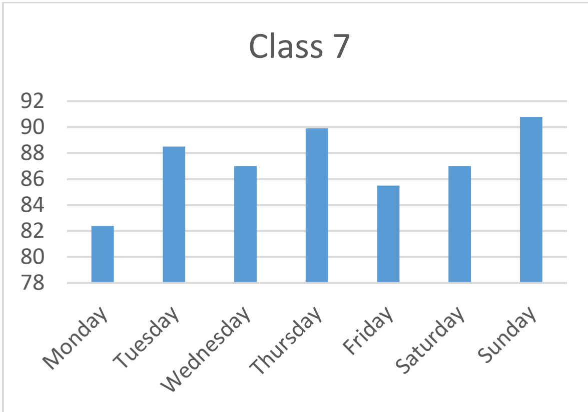
Pavement type	Categories of vehicles	Day 1	Day 2	Day3	Day4	Day5	Day6	Day7
Flexible	Class1	77.0	75.0	78.1	72.2	75.0	77.7	83.4
	Class2	85.8	88.0	89.5	88.5	89.0	86.2	85.5
	Class3	71.2	80.5	69.3	79.0	76.8	68.0	80.2
	Class4	75.0	78.2	80.1	77.7	89.9	79.3	83.3
	Class5	86.5	89.2	88.8	99.5	83.4	89.9	98.3
	Class6	93.4	90.5	93.2	94.0	94.9	98.2	95.9
	Cass 7	82.4	88.5	87.0	89.9	85.5	87.0	90.8
	Class 8	84.3	88.5	89.3	87.9	90.1	86.2	75.7
Rigid	Class 1	71.2	84.3	77.8	79.3	87.4	80.3	83.2
	Class 2	96.5	73.2	74.2	78.5	90.2	88.0	85.5
	Class 3	89.7	87.6	89.0	82.9	84.6	89.0	86.2
	Class 4	88.2	84.5	90.4	93.2	85.5	87.8	90.6
	Class 5	87.3	83.4	87.3	88.2	90.5	93.2	95.2
	Class 6	89.0	88.3	93.4	93.9	87.8	91.0	86.6
	Class 7	89.2	93.8	92.6	90.3	95.2	94.5	95.4
	Class 8	88.0	90.3	92.2	90.1	93.2	89.9	93.3
Composite	Class 1	76.7	77.7	75.6	79.8	70.0	80.4	84.4
	Class 2	69.8	75.0	71.0	74.2	72.9	70.3	70.8
	Class 3	63.5	67.2	68.8	69.5	66.6	69.0	64.4
	Class 4	58.3	57.8	63.3	60.2	59.8	60.6	60.0
	Class 5	66.4	65.7	70.4	72.3	69.7	70.0	71.3
	Class 6	80.3	75.6	78.8	75.4	79.6	80.5	81.4
	Class 7	80.8	87.3	79.6	75.7	89.2	81.1	80.3
	Class 8	87.3	94.3	79.5	86.9	90.7	88.9	96.8

4.10 The total average vale

Pavements / Vehicle class	Flexible	Rigid	Composite
Class 1	77.2	80.5	77.8
Class 2	87.5	82.3	72.0
Class 3	75.0	87.0	67.0
Class 4	80.5	88.6	60.0
Class 5	90.8	89.3	69.4
Class 6	94.3	90.0	78.8
Class 7	87.3	93.0	82.0
Class 8	86.0	91.0	89.2

Fig 4.1 BAR CHARTS FOR FLEXIBLE PAVEMENT





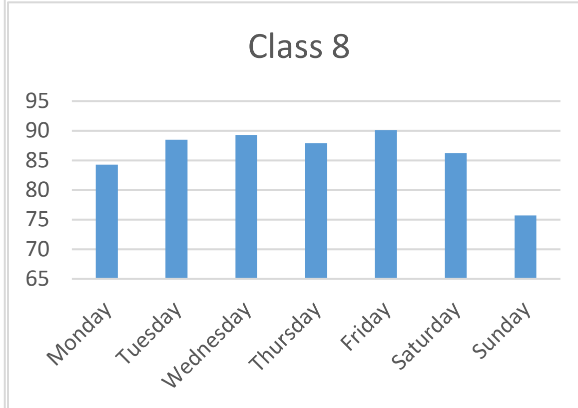
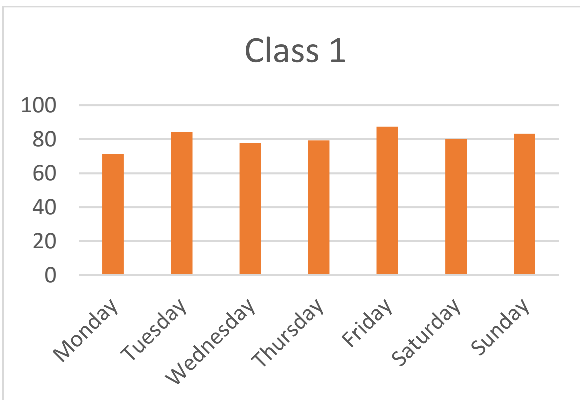
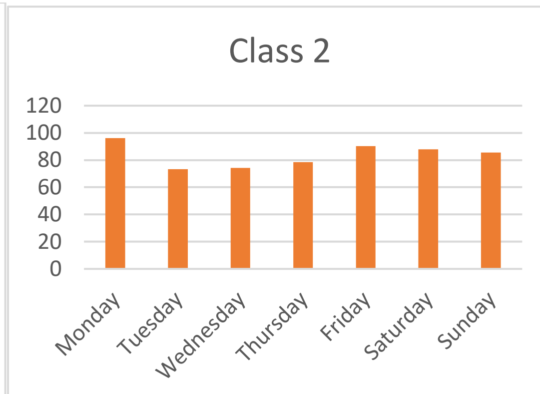
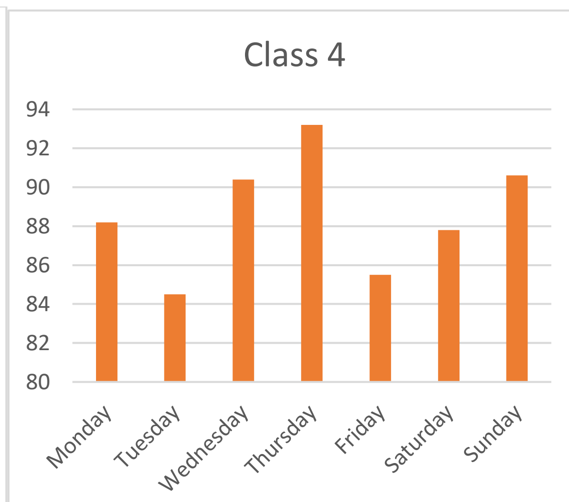


Fig 4.2 BAR CHARTS FOR RIGID PAVEMENT





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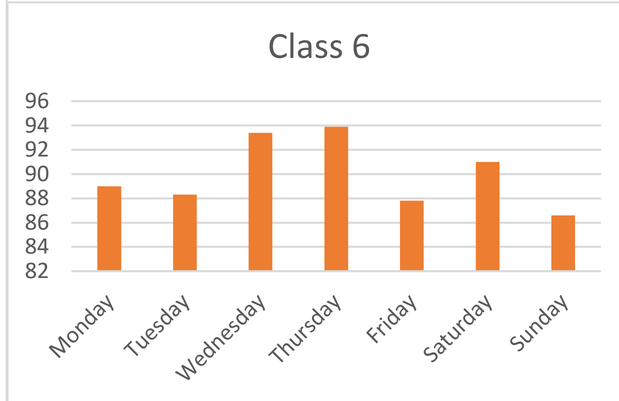
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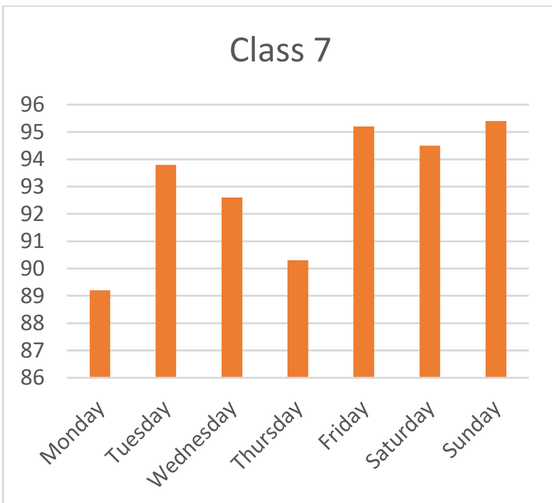
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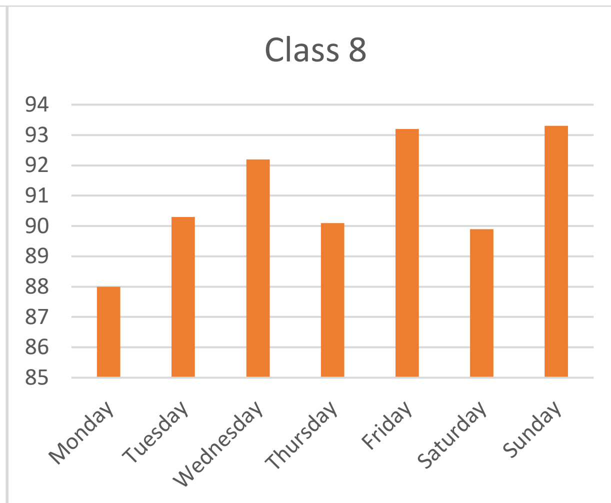
Class 8
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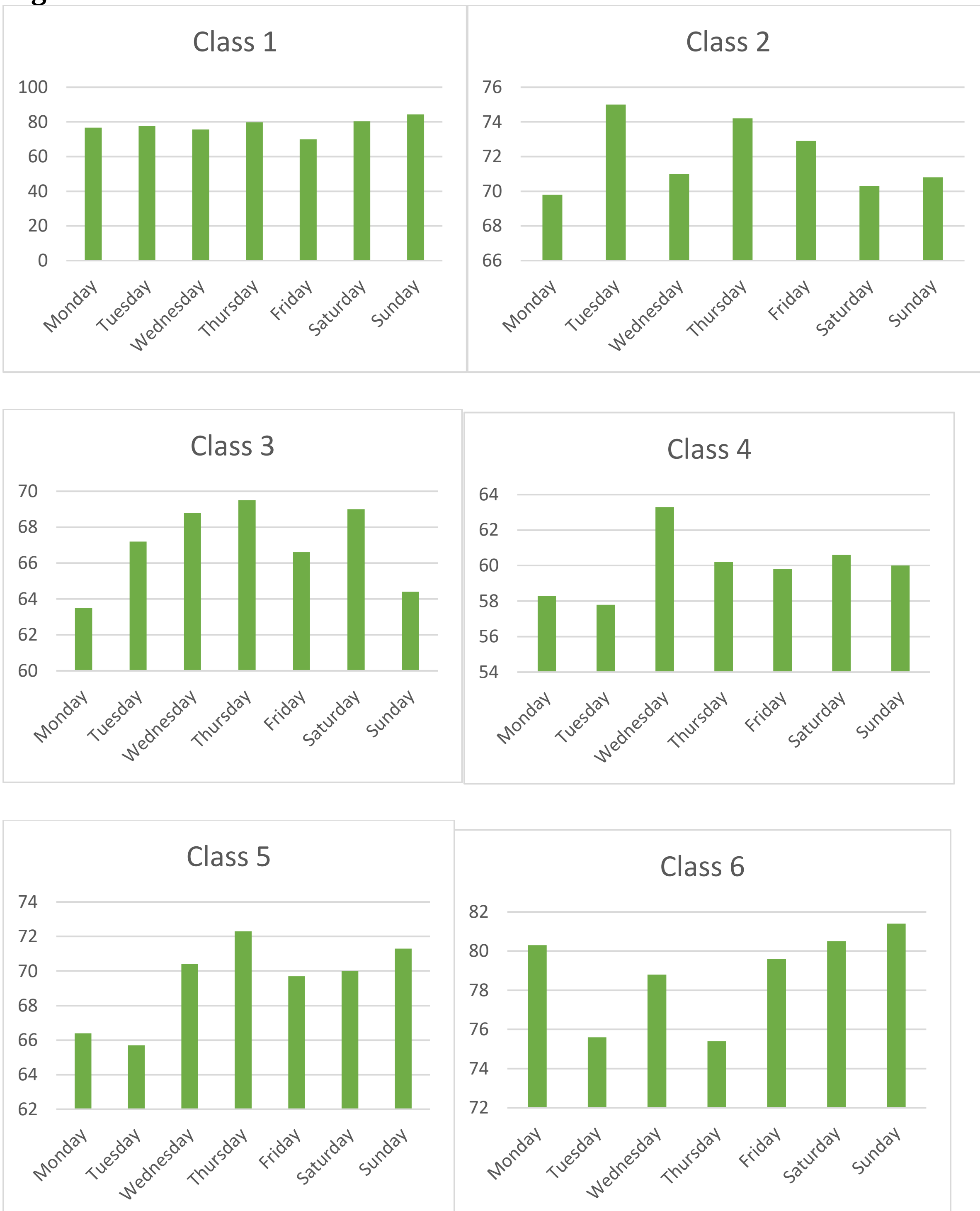
Fig 4.3 BAR CHARTS FOR COMPOSITE PAVEMENT



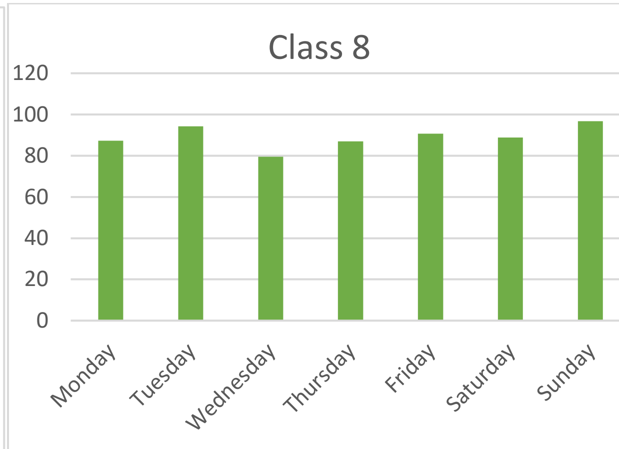
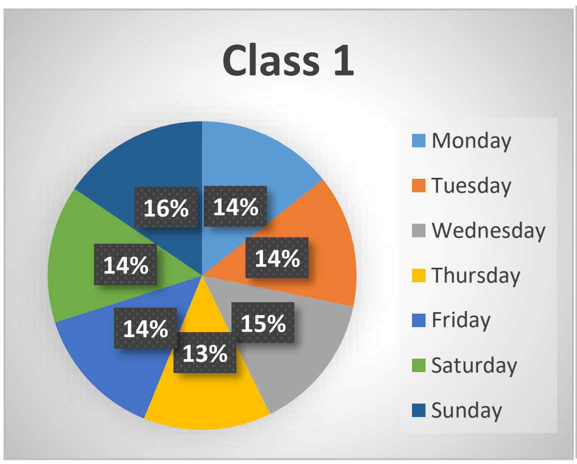
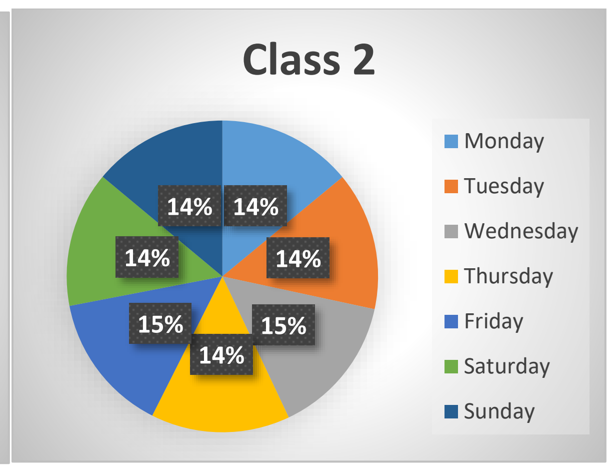
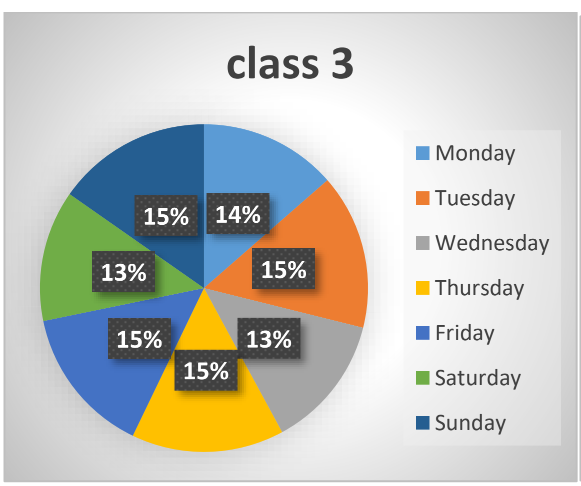
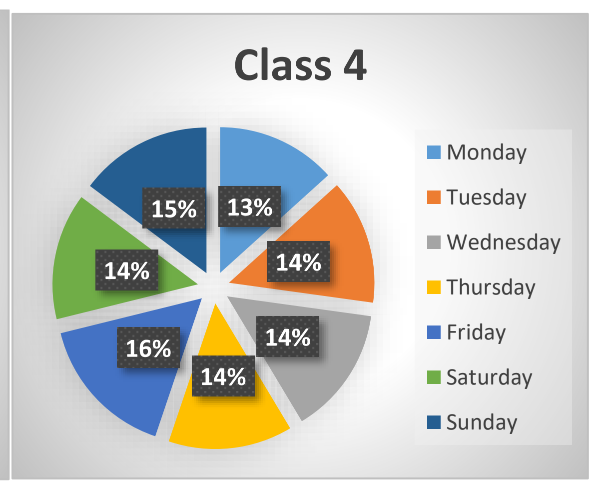


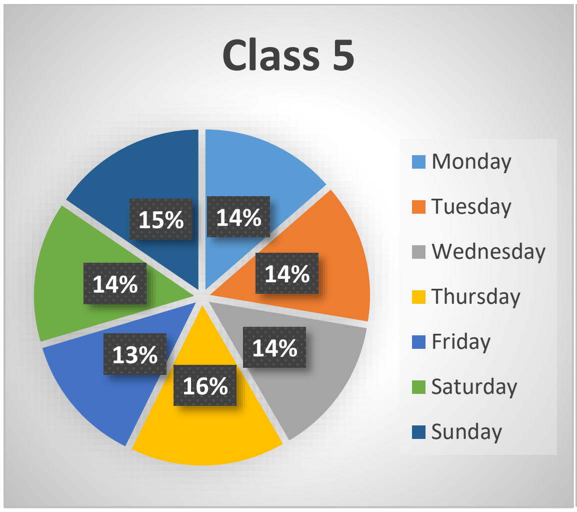
Fig 4.4 PIE CHARTS FOR FLEXIBLE PAVEMENT







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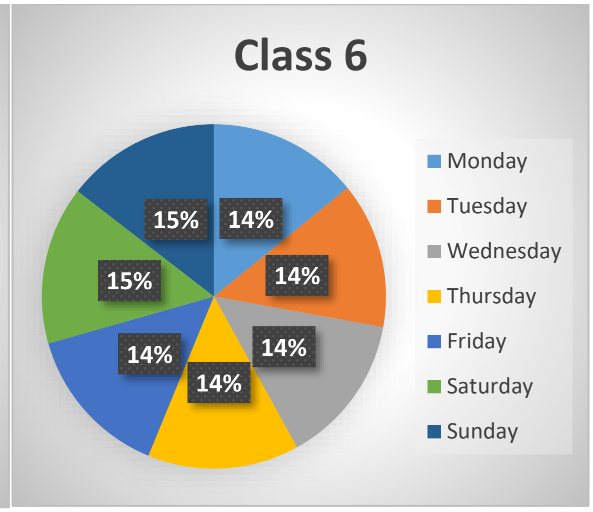
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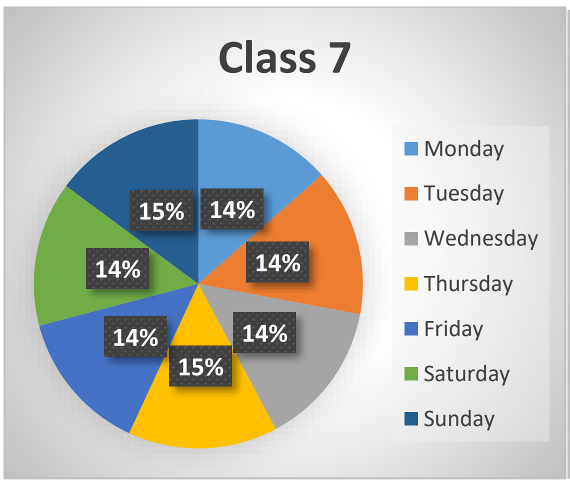
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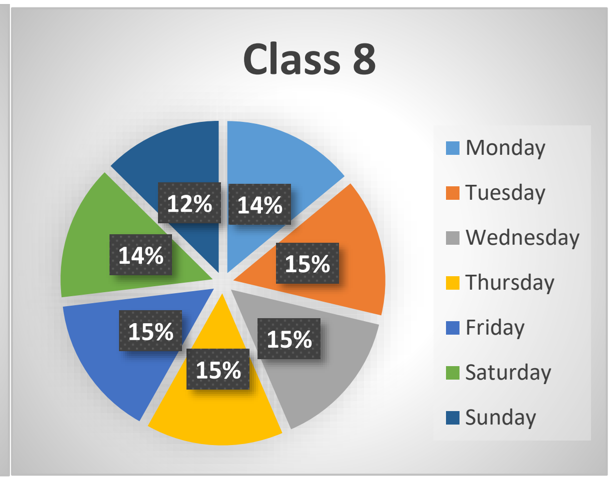
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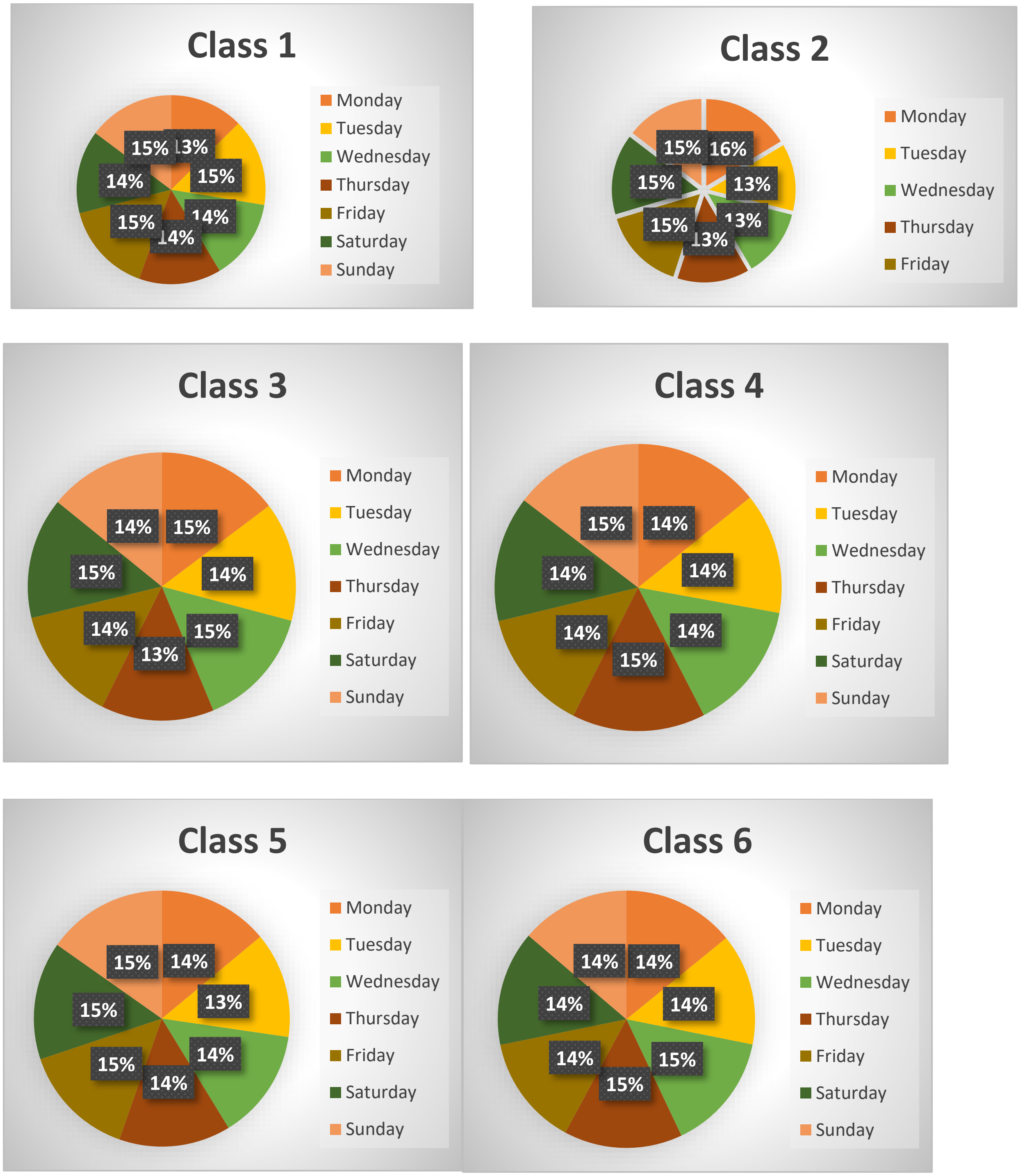
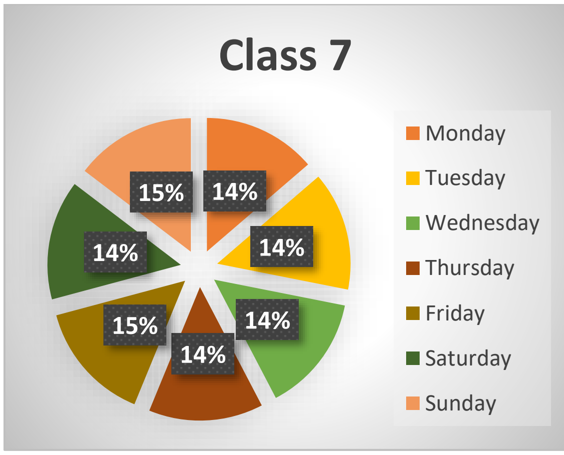
Fig 4.4 PIE CHARTS FOR RIGID PAVEMENT





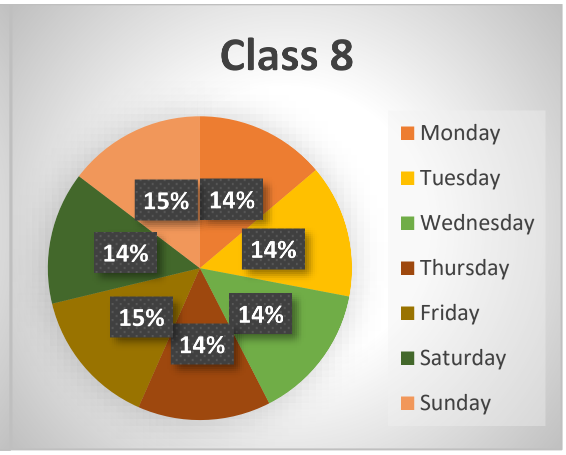
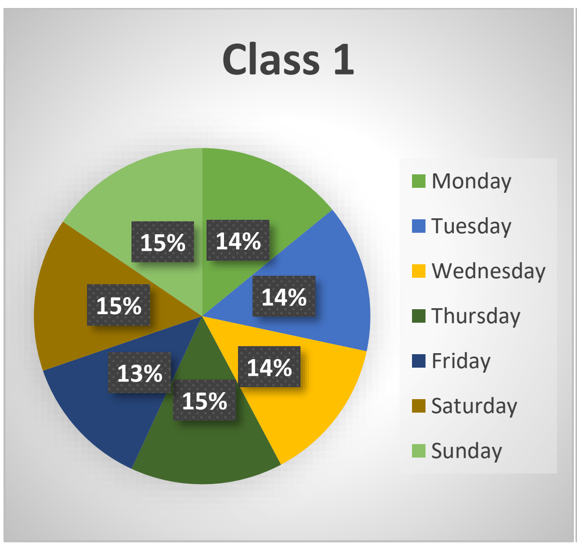
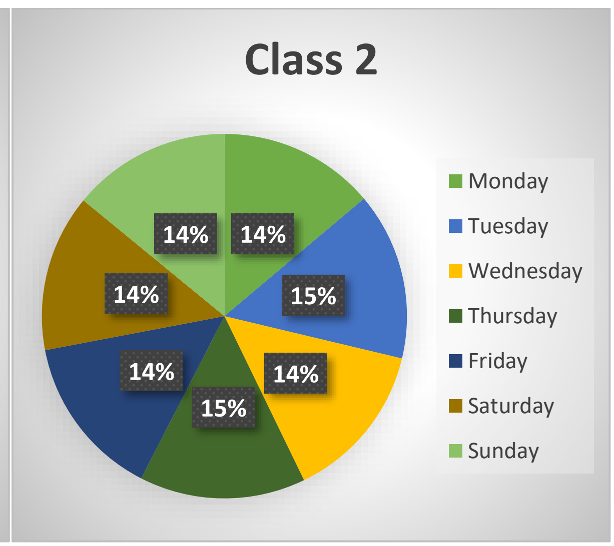
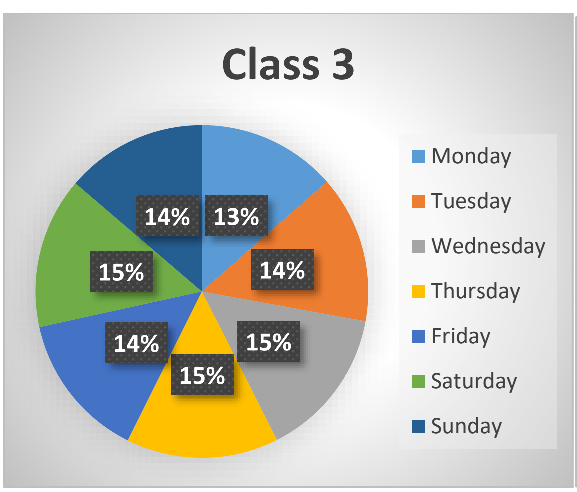
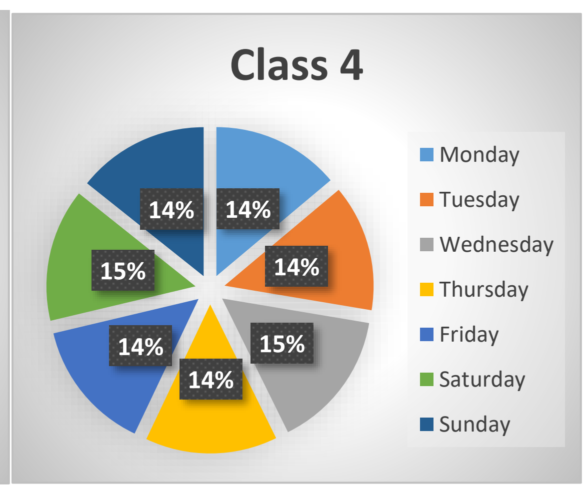


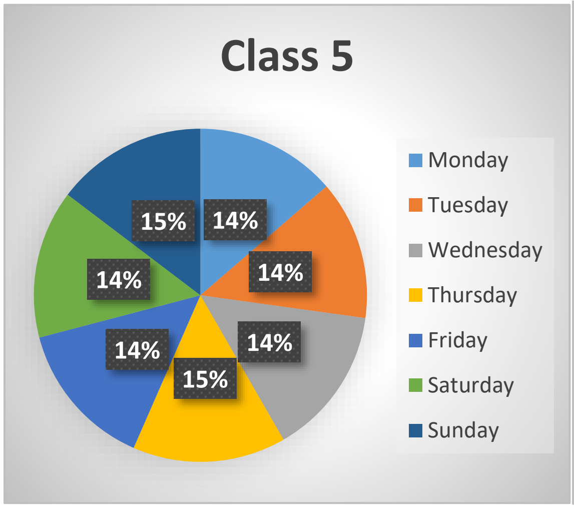
Fig 4.5 PIE CHARTS FOR COMPOSITE PAVEMENT







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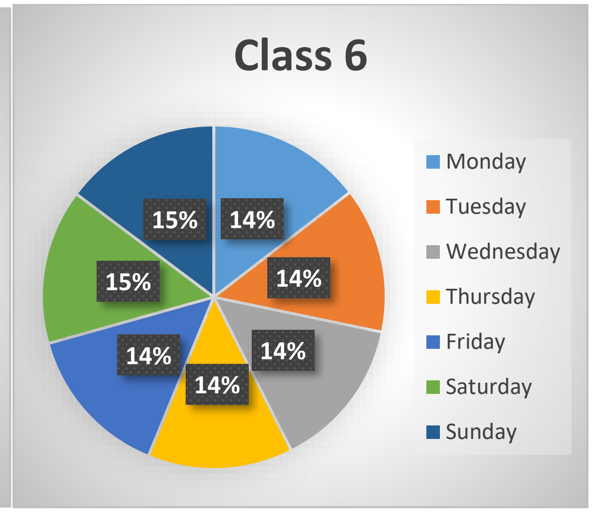
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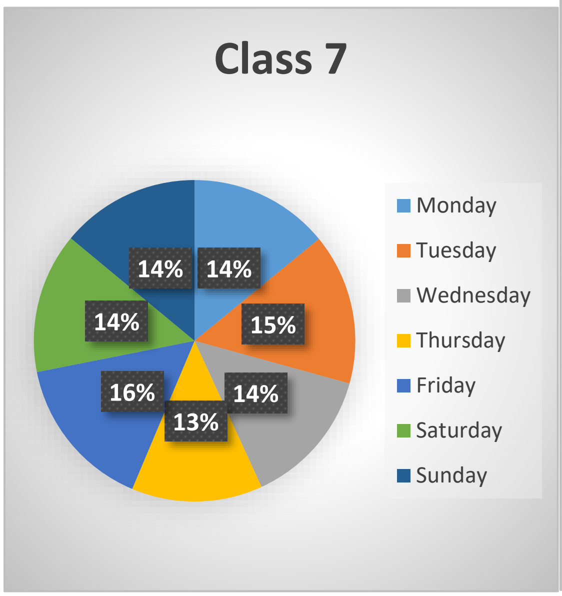
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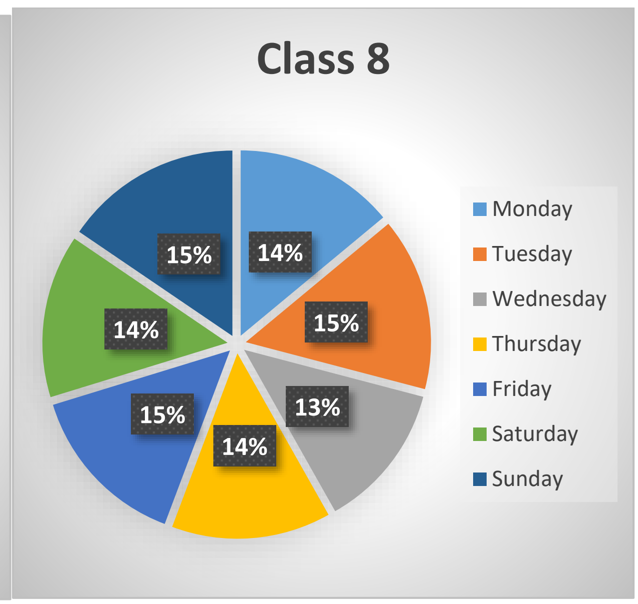
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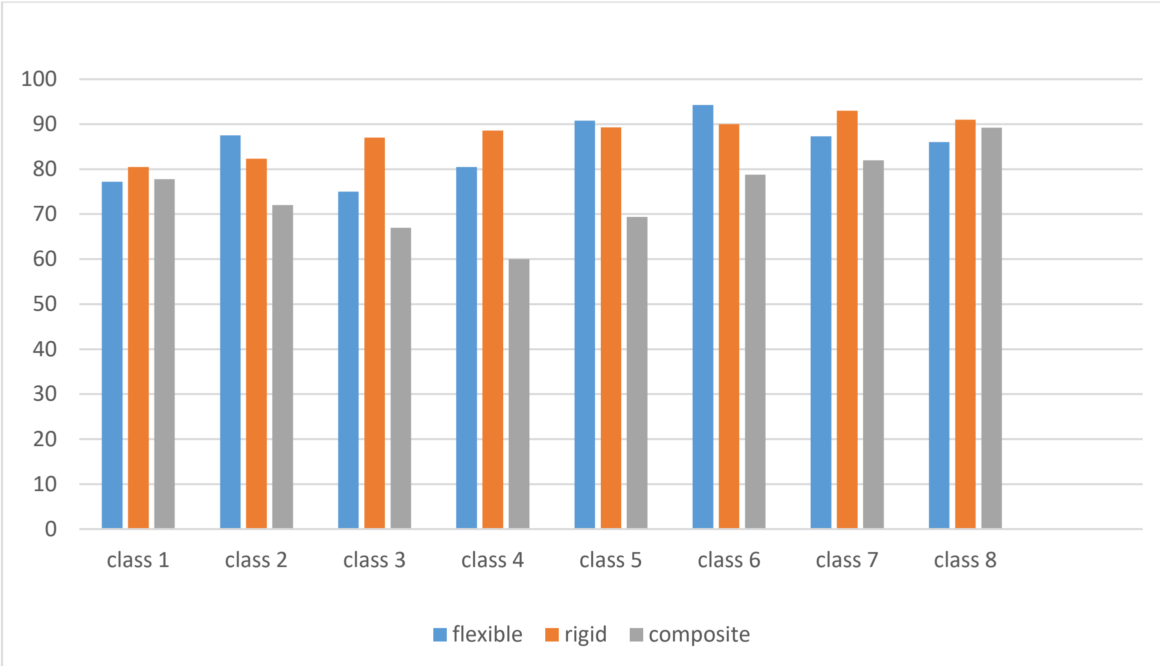
BAR CHART SHOWING THE THREE PAVEMENTS



CHAPTER FIVE

5.0 CONLUSION AND RECOMMENDATION

5.1 CONCLUSION

In this study, a thorough evaluation of the traffic noise levels at the three pavements sampling locations. The study's literature review included some previously published works. Understanding of earlier research and the best strategy for achieving the project's goals were offered through the literature reviews.

Noise pollution levels were measured at three (3) locations. The monitoring locations included; Ekosodin junction (flexible pavement), Uselu park (rigid pavement) and Igun street (composite pavement). Using the noise data gathered during the measurement sessions, the study was able to determine the peak noise levels at each of the study locations. The findings of this study indicate that, in comparison to monitoring stations at traffic locations, the daily noise level, average noise level, and peak noise level are greater at traffic locations near passenger loading parks. The increased traffic in certain places is to blame for this.

5.2 RECOMMENDATION

The National Environmental Standards and Regulations Enforcement Agency (NESREA) and other noise control stakeholders ought to intensify their enforcement efforts and inform the public about the drawbacks of making inappropriate or unnecessary use of sound. Access hours, vehicle types, and speed should all be regulated or restricted. Enforcing the laws, regulations, and recommendations on environmental pollution will significantly lessen the problem of noise pollution

It is necessary to ban vehicles that fail a fitness test and make intrusive noises. Effective modifications should be made to vehicle suspensions and exhaust silencers to reduce rolling stock and exhaust noise.

Creating acoustic or sound barriers and planting trees. The utilization of organic noise barriers, such as flora, is also useful at attenuating noise. Other advantages include the reduced maintenance costs and the beauty of the surrounding scenery brought about by the presence of plants.

Speed limit should be enforced, with strict punishment for offenders

The use of needless horns on roads should be avoided. Drivers and passengers must adhere to traffic laws, and penalties for breaking the law must be applied strictly.

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