EVALUATION OF SPEED BUMPS AT OSASOGIE COMMUNITY OF EGOR LOCAL GOVERNMENT AREA, BENIN CITY, WITH THE USE OF GEOSPATIAL TECHNIQUES

BY

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CERTIFICATION

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DEDICATION

I dedicate this work to Almighty God who has been there right from the beginning to this very point. I also dedicate this work, to the memory of my beloved father, Late Mr J.U Azih, whose unwavering love, encouragement, and wisdom have been a constant source of inspiration throughout my academic journey. Also to my mother, my brother and my two sisters for their relentless support and compassion towards my pursuit for B.Eng. Degree in Civil Engineering in University of Benin.

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ABSTRACT

This research work, evaluated the speed bumps in the Osasogie Community with the use of geospatial techniques. Speed bumps, are important traffic calming devices seen on our roads, which help to physically reduce traffic speed.

The work was done in two phases, which were the field study and the questionnaires. During the field study, the coordinates of each speed bump was taken as well as the geometric properties of each speed bump which were the height, length, width and the clear spacing. A comparison was done on the geometric properties of these speed bumps, using the standard of the 'Federal Heights Municipal Code of Colorado, USA'. A handheld GPS receiver was used to take the coordinates, while measuring tapes were used to measure the geometric properties.

The standard width of speed bump was between 0.6m and 1.2m, the standard height was between 0.07m and 0.1m, while the standard length was between 3.65m and 5m. In total, 22 speed bumps were analyzed from 4 streets, of which only 4 speed bumps met the design criteria, which was 18.18% of the entire speed bumps. Also the clear spacing of the speed bumps in all the locations, did not meet the design criteria, as they were either too close to each other, or too far apart. From the questionnaire survey, it showed a vast variation in the response, based on the point of view of each respondent, however, majority of the respondents, were satisfied with the application of speed bumps, in the study area.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Transportation delivers immense socioeconomic benefits to any modern society. Road transportation, in particular, is the lifeblood of most developing countries, as other modes of transit are either non-existent or in their infancy. It accounts for 80% and 90% of goods and passenger traffic in Africa, respectively (United Nations Economic and Social Council, 2009). Traffic flow in cities is the result of both the movement of people and products over land. The kind and level of land use that is done, as well as the transportation amenities that are offered, are directly related. Land use is a major predictor of activity, or trip creation, which requires streets and transportation networks for movement.

The phrase "traffic management" refers to a number of methods for addressing highway and traffic-related problems. It can be defined as the overall process of changing the use of an existing road system to improve traffic operations without resorting to significant new construction. According to Adebisi (2004), it is a method for organizing and managing a roadway and highway network in an urban area.

The operation of a state relies heavily on public safety (Borucka, 2020). This entails making sure that the infrastructure for transportation and other systems operates properly. The maximum level of protection for their citizens may be provided in safe communities by utilizing modern technology and the data they collect. There are numerous factors that determine this level, including low crime rates, the frequency of unexpected and severe weather occurrences, and the amount of automobile accidents (Borucka et al., 2020). Another crucial element in the city is the safety of the road traffic.

One of the main causes of death in Nigeria is cited as being traffic accidents. In reality, scarcely a day goes by without hearing of a traffic accident that caused the loss of life, property, or injuries that resulted in temporary or permanent impairment (NBS, 2020). According to a Dennis Amata report from January 17th, 2022, Nigerian road traffic accidents have claimed 41,709 lives in the past eight years. The World Health Organization (2018) estimates that Africa is one of the regions most impacted by traffic accidents, with 26.6 road fatalities for every 100,000 people worldwide.

It is estimated that each year more than 1.2 million people worldwide die as a result of road accidents and around 50 million are injured. Consequently, traffic calming measures have been used successfully in cities for decades. They make it possible to reduce the negative effects of the use of motor vehicles and influence the behavior of drivers so as to improve the conditions for motorized and non-motorized street users. These calming measures include tools for the optical traffic guidance, marking objects on the road edge, closing roads, informing and warning drivers, securing works or conducting supervision. These are also guide posts, edge posts, signs and warning lights. One of the road safety devices is speed bumps, which are used to physically limit the speed of vehicles. (Kosakowska, 2022)

According to Abdel-Wahed and Hashim (2017), speed bumps can be sinusoidal, circular, or parabolic in shape. They normally measure 3.7 to 4.3 meters in length and 76 to 100 mm in height (Federal Highway Administration, 2020). The height and length of a speed hump affect the speed at which a vehicle travels over it. In order for vehicles to pass over the hump safely and comfortably, they can slow down to a speed of 30 km/h (Afukaar and Damsere-Derry, 2010; Federal Highway Administration, 2020; Yaacob and Hamsa, 2013). With a 30 km/h crash speed, vulnerable road users have a higher chance of surviving (Wegman and Aarts, 2006), and this significant speed reduction also reduces crashes by 22%–43% (Arbogast et al., 2014; Rothman et al., 2015).

J. Tester et al. (2004) prove that speed bumps are less likely to injure children in their vicinity. S. Shwaly et al. (2018) write that speed bumps reduce vehicle speed, traffic volume or the number of accidents, but also that using them has led to the damaged road surface and vehicles, especially when they have been poorly designed or if they have been used in the event of increased safety on an incorrectly designed road.

1.2 STATEMENT OF THE PROBLEM

The issue of accidents in road transportation in Nigeria is significant due to the poor road network flow patterns and poor traffic control measures. Traffic accidents claim both property and life which makes it necessary for the implementation of traffic engineering and management tools such as speed limiters which can assist in reducing accidents.

As the rate of accident increases in both developing and developed countries, increased measures must be put in place to avoid loss of lives, therefore traffic calming is of high importance. Speed reduction strategies need to be put in place for safe usage of road, against careless behaviors of drivers and over speeding. Also the design of these devices must be proper and follow the appropriate guidelines (Ullah et al., 2016). The main traffic calming device used in Nigeria is the speed bump which helps in the reduction of traffic speed especially in very busy roads, like in residential areas.

Despite their widespread use, however, little thought has been given to the design of these devices, and this haphazard approach frequently results in faulty construction. It is therefore important that speed bumps are built correctly, as even minor deficiencies can result in vehicle damage, which can cause passenger discomfort and, in severe cases, injuries. (Hessling and Zhu, 2008).

In light of the claim, this study evaluated the location and implementation impact of speed bumps in Nigerian metropolitan areas using the Osasogie community as a case study.

1.3 AIM AND OBJECTIVES

The aim of this study is to analyze the effect of speed bumps, as a traffic calming device on some roads of Osasogie community in Edo state, Nigeria.

The objectives of the study are to;

1. Determine the geometric properties of speed bumps, and compare with a standard
2. Determine speed bump location and area mapping with the use of Google Earth Pro.
3. Assess the impact of speed bumps on vehicles
4. Determine the significance of speed bumps in terms of the safety of the inhabitants
5. Determine the effect of speed bumps on drivers.

1.4 SCOPE OF THE STUDY

This study was carried out using Osasogie community as case study. The location of the speed bumps and the area was mapped using Google Earth Pro software. Measurements of height, length, width, and spacing of speed bumps were included in the list of activities. Questionnaires were handed out to collect data on how speed bumps affect motorists, automobiles, and pedestrians. Following the completion of all physical observations and experiments, they were then evaluated against the Federal Heights Municipal Code, of Colorado, USA.

1.5 JUSTIFICATION OF THE STUDY

This research work shows that the need for the safety roads in Nigeria cannot be over emphasized. Moreno and Garcia (2013) states that, almost half of all deaths on the world roads are among those who are less protected, motorcyclists, cyclists and pedestrians. This study is of importance as it helps to define effects of vehicles on most roads in Osasogie community in terms of traffic and analyzing how traffic can be reduced by application of speed bumps on most roads. In Nigeria, the increasing rate of accidents on roads is due to over speeding of vehicles.

Speed bump installation have increased pedestrian safety, reduced traffic volumes and also crash risk (Taylor, 2021). It is important to know that speed bumps are effective in minimizing the vehicular speed, thereby preventing injuries and death on roads.

This research work will therefore help to determine the importance of speed bumps on vehicle and drivers, and how it leads to the safety of the inhabitants.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 TRAFFIC CALMING

In the past traffic calming has been used to discuss strategies in traffic management and urban traffic policies especially in developed countries. Recently traffic calming can be used to describe a much wider context of traffic management in both developed and developing countries like Nigeria.

Traffic calming involves programs or actions that can help to minimize street traffic and slow down vehicles which are within residential areas so as to make the environment a lot safer by implementing some measures such as the removal of excessive traffic, reduction of vehicular speed, improvement of the safety of both drivers and pedestrians (Pharoah and Russell, 1991). Traffic calming measures refers to either volume control measures or speed control measures. Volume control measures limit vehicular traffic by resisting access to a particular road, street or lane, while speed control measures are physical devices which are employed in other to reduce the average speed of vehicles that ply the road (Ewing and Brown, 2017).

2.1.1 HISTORY AND ORIGIN OF TRAFFIC CALMING

The concept of traffic calming began from the Netherlands. As automobiles became popular the in the early 1960's the traffic volume began to increase. In the 1970's concerns about the traffic volume and speed began to arise and then the first calming device was installed in the city of Delft which was a 3 inch (7.62cm) speed bump constructed at the end of an alleyway (Schlabbach, 1997).

The success of this speed reduction measure led other European nations to experiment with these devices

In 1977 Germany carried out different experiments which were rotary intersections, narrowing and textured surface grounds. These methods also proved to be successful and other counties such Norway, Sweden, Switzerland, England, France, Austria, Israel, and Japan began to implement these measures to improve their traffic situations (Ewing, 1999).

2.1.2 TRAFFIC CALMING DEVICES

Speed management has become a very vital topic in today's world. With the introduction of horizontal and vertical calming devices measures, road users have now been enforced physically to select appropriate speeds on streets and roads, although in practice it doesn't always ensure compliance to speed limits (Vaitkus et al., 2017). Some of these calming devices include;

i. **20mph Speed limit:** Lowering speed limits alone may not have the desired effect. National guidance advises that 20mph limits should be self-enforcing. Sometimes it is necessary to install traffic calming measures to encourage compliant speeds.

FIGURE 2. 1 20MPH SPEED LIMIT (SOURCE: MUSEPRINTABLES, 2023)

ii. **Road Humps:** Road humps stop people speeding up rather than slow them down. Extra slowing features at each end of a run of hump will be provided. They are suitable for residential areas but are not acceptable on bus routes. Effectiveness decreases as spacing increases

FIGURE 2. 2 ROAD HUMP (SOURCE: ROGER, 2017)

iii. **Speed tables:** Like road humps but longer and with fattened top. Sometimes used to give pedestrians a level crossing between footways. They can also be used throughout a junction; especially useful when there are a lot of pedestrians. If they are long enough, they provide a smoother ride for buses than humps

FIGURE 2. 3 SPEED TABLE (SOURCE: FAKILE, 2016)

iv. **Speed cushions:** Raised rectangular areas there can be one, two or three, depending on the width of the road. Like humps they are most suitable for built up areas and need slowing features. They do not slow speeds to same extent as humps but do give emergency vehicles and buses a smoother ride.

FIGURE 2. 4 SPEED CUSHION (SOURCE: RANTZ, 2016)

v. **Rumble strips:** (also known as sleeper lines or alert strips) are a road safety feature to alert inattentive drivers of potential danger, by causing a tactile vibration and audible rumbling transmitted through the wheels into the vehicle interior. A rumble strip is applied along the direction of travel following an edge line or centerline, to alert drivers when they drift from their lane. Rumble strips may also be installed in a series across the direction of travel, to warn drivers of a stop or slow down ahead, or of an approaching danger spot.

FIGURE 2. 5 RUMBLE STRIPS (JAMES, 2023)

vi. **Chicane:** is a serpentine curve in a road, added by design rather than dictated by geography. Chicanes add extra turns and are used both in motor racing and on roads and streets to slow traffic for safety. For example, one form of chicane is a short, shallow S-shaped turn that requires the driver to turn slightly left and then slightly right to continue on the road, requiring the driver to reduce speed.

FIGURE 2. 6 CHICANE (SOURCE: EDUCALINGO, 2023)

vii. **Lane width restrictions:** Narrowing lanes, using traffic island or road markings can give the impression of a more confined road and result in reduced speed. If a road is narrowed, special attention must be given to the needs of cyclists.

FIGURE 2. 7 LANE WIDTH RESTRICTIONS (SOURCE: BROMLEY, 2009)

viii. **Pedestrian crossing:** Crossing may encourage more people to walk by improving safety and reducing delays crossing busy roads. They can be provided where there is a concentrated crossing movement, but no need of adequate visibility.

FIGURE 2. 8 PEDESTRIAN CROSSING (SOURCE: SHANEGENZIUK, 2013)

ix. **Pedestrian refuges:** Refuges allow pedestrians to cross one stream of traffic at a time. They are useful where the concentration and number of pedestrians is low. By narrowing the road, they reduce speed. The road needs to be wide enough to allow for a suitable refuge and the safe passage of vehicles and cycles.

FIGURE 2. 9 PEDESTRIAN REFUGES (SOURCE: ROSEHILL, 2023)

x. **Roundabouts:** Equal priority in all directions can slow traffic. There needs to be a reasonable large flow on all arms for this to be effective. Roundabouts can make some turns easier which can lead to rat-running. They can be expensive and also need to work to slow down traffic on the approach to the roundabout. Mini-roundabouts take up less space but need to be in street lit areas

FIGURE 2. 10 ROUNDABOUT (SOURCE: NAIJAUTO, 2022)

xi. **One way road:** Control the circulation of traffic but can lead to faster speed as there is no opposing flow. Traffic can increase on other roads so there needs to be a suitable route for traffic travelling in the other direction. One way streets can attract new traffic so traffic may not decrease.

FIGURE 2. 11 ONE WAY ROAD (SOURCE: GLOBAL DESIGNING CITIES INITIATIVE, 2023)

2.1.3 VOLUME CONTROL DEVICES

Most times when heavy construction work, major rehabilitation project or maintenance of road is ongoing in a particular location, the need to reduce traffic volume may arise. Volume traffic devices are used when the main goal is to reduce the traffic volume in an area. They are physical devices that discourage or sometimes even prohibit traffic movements. The most common volume control devices used in cities and towns are the full or partial closure. Full closure means that the whole road carriage way will be closed to all vehicles but opened to pedestrians. Examples of full closure include Dead-end Street and Cul-de-sac. Half or partial closure exist when one lane of traffic is blocked for a short distance (Smith et al., 2002).

2.1.4 SPEED CONTROL DEVICES

Speed limit signs are widely distributed throughout a network of roads, and they are placed where the posted speed limit changes. An engineering study should be done before setting a speed restriction within a speed zone, and the posted speed limit should be no more than 5 mph slower than the 85th percentile free-flow traffic speed. According to (National Research Council, 1998), speed limits are employed to improve road safety and can have either a limiting or a coordinating purpose. The maximum speed restriction is set by a limiting function, which can lessen the likelihood and severity of accidents. A coordinating function lowers the variance in speed along the route, resulting in a more consistent traffic flow.

Since the 1960s, changeable message signs (CMSs), also called "dynamic message signs" or "variable message signs," have been put in place on American roads. According to Bertini et al. (2006), these signs are intended to reduce traffic delays, accident risks, or unusual roadway conditions. They also delay or prevent congestion and balance traffic flows during peak hours. An operator at a traffic management center may initiate a dynamic message in response to sensor inputs deployed in the road network or preplanned message plans.

2.2 SPEED BUMPS

The terms Speed humps, speed bumps, speed tables or speed breakers can be used interchangeably, however the terminologies used can be slightly different for different regions.

A speed hump is a raised area in the roadway pavement surface extending transversely across the travel way. They are sometimes referred to as “pavement undulations” or “sleeping policemen”. Most agencies implement speed humps with a height of 3 to 3.5 inches (76 to 90 mm) and a travel length of 12 to 14 feet (3.7 to 4.3 m). Speed humps are generally used on residential local streets.

A speed bump is also a raised pavement area across a roadway. Speed bumps are typically found on private roadways and parking lots and do not tend to exhibit consistent design parameters from one installation to another. Speed bumps generally have a height of 3 to 6 inches (76 to 152 mm) with a travel length of 1 to 3 feet (0.3 to 1 m).

Speed tables are essentially flat-topped speed humps, made up of textured material on the flat section with asphalt or concrete for the approaches. It can also be referred to as “trapezoidal humps” or “speed platforms”. Speed tables generally consist of 10 foot (3.1 m) plateau with 6 foot (1.8 m) approaches on either side that can be straight, parabolic or sinusoidal in profile. The longer lengths of speed tables provide a gentler ride than speed humps and generally result in vehicle operating speeds ranging from 25 to 30 mph (40 to 48 km/h) on streets depending on the spacing between speed tables. Speed tables are generally used on residential collectors, emergency routes or transit routes

FIGURE 2. 12 SPEED BUMP (SOURCE: CERES, 2022)

In this study, the term speed bump with be adopted which is the most common type of traffic calming devices used in Nigeria, for vehicle speed control. Speed bumps are therefore raised pavements spanning across or partly across a roadway which can be used in a one way or two way street. The major application of speed bumps on road is to reduce the average speed of vehicles on a section of the road. According to a report by (Hallmark et al., 2002; Zech et al., 2009), vehicle speed can be reduced to up to 18 to 20 per cent of their travel speed, when approaching a speed bump. The reduction of the speed of vehicles on the roadway is also a function of the spacing of the series of speed bumps which have been installed on the road (Ewing and Hodder 1996; Garcia et al., 2012), which according to the Indian Roads Congress is within 100 to 200m.

(Solagberu et al., 2015) conducted a pedestrian injury research in Nigeria's most densely populated city and discovered that speed arrestors handle traffic complexity in favor of walkers rather than autos.

Similarly, (Paddison and Tiafack, 2022) conducted research on the accident environment in Cameroon and discovered that adding a speed arrestor is beneficial in reducing the frequency and severity of vehicle incidents. Similarly, officials in Senegal (Tchanche) believe that adding a speed arrestor is necessary due to high speeds and numerous accidents.

While speed bumps helps in the reduction of traffic speed especially in very busy roads, like in residential areas, it has also proven to have some other disadvantages associated with it such as increase in travel time, passengers' discomfort, increased cost of maintenance of vehicles and increase in environmental pollution (Kiran et al., 2020).

According to (Leslie and Bunte, 2000) it can be seen that a delay of 10 seconds and occur per hump. This seems to be quite a short time but when accumulated over an entire road way for the series of speed bumps can have a significant effect on the total travel time.

The low speed brought about by traffic calming measures have been seen also to increase fuel consumption and have impacts on the environment due to the increased emission of gases such as CO, NO2, and Hydrocarbon compounds. (Ahn and Rakha, 2009) showed an increased emission of 51 percent of HC, 44 percent of CO, 110 percent of NO2 and 52 percent of CO2 for vehicles while moving on a roadway with series of speed bumps, as compared to a roadway without speed bumps.

2.3 GENERALIZED STANDARDS AND GUIDELINES

The following are the guidelines and standards for the installation of speed humps, according to the Federal Heights Municipal Code, of Colorado, USA:

1. Speed bumps, can only can be installed only on residential streets

2. They should be installed on non-emergency vehicle routes

3. Installation should not be closer than 200 feet from an intersection

4. They should be visible for a minimum of 200 feet

5. They should be installed only on straight sections of streets only

6. They should not alter designed drainage pattern

7. Streets without curbs should have reflector and delineator posts installed adjacent to the edge of street pavement at specified intervals and distances either side of speed hump

2.3.1 SPEED BUMP DESIGN GUIDELINES

The design guidelines of speed bumps according to the Federal Heights Municipal Code, of Colorado, USA include:

1. Speed bumps should be constructed of either concrete (plain or colored) or asphaltic concrete

2. The height of bump should be between 3 inch and 4 inch (dependent upon particular case) ±1/4 inch

3. The Length of bump base should be either 12 feet or 16 feet (4.17% slope)

4. Sides of bump should be tapered to edge of gutter pan

5. Bumps should be delineated by striping with white paint or tape (8 inch width)

6. Warning signage should be installed before and at speed hump

7. Speed bumps should be spaced at approximately between 200 feet to 400 feet intervals

8. Speed bumps should be installed as close as possible to street lighting for maximum illumination.

2.4 MATERIALS AND COMPOSITIONS

Speed bumps can be made of different materials, such as asphalt, concrete, recycled plastic, metal, or vulcanized rubber. Generally in Nigeria, majority of vertical deflection devices are made of asphalt or concrete. These materials are more permanent and are more effective in slowing traffic because to their rigidity. They are quite difficult to form into uniform shapes and dimensions. However rubber products are also used and they are pre-shaped into conventional sizes, which are relatively simpler to install or remove.

2.5 TYPES OF SPEED BUMPS

Speed bumps are often classified into six types based on their locations. They are Highway speed bumps, driveway speed bumps, gravel road speed bumps, earth road speed bumps, garage speed bumps, and parking lot speed bumps. Their names refer to the places where they are used.

a. **Highway speed bumps**: sometimes speed bumps can be built on major highways. Their primary objective is to control traffic flow by setting speed limitations on moving vehicles.

   Speed bumps are typically employed on residential roads rather than main routes.

   It is due to the high speed of automobiles on major roadways. A collision induced by road bumps or speed humps can cause vehicle damage. It may also interfere with the path of emergency vehicles.

   Highway speed bumps can also be utilized on other roads and city streets where there is more interaction between people and vehicles. Installing them in front of traffic lights or pavement markings can force people to stop at a red light or follow the road markings.

Rumble strips are commonly found on major roads. These strips are either along the center line of the road or on its shoulders. They generate vibration and noise, alerting the negligent driver to the hazard.

According to research from the Federal Highway Administration, speed bumps and rumble strips minimize collisions between automobiles and pedestrians dramatically.

FIGURE 2. 13 HIGHWAY SPEED BUMP (SOURCE: SINO, 2022)

b. **Driveway speed bumps:** Drivers are often warned of the presence of pedestrians on a driveway, street, or pavement by speed bumps. They provide a safe crossing zone for pedestrians using the pedestrian crossing, crosswalk, and sidewalk. They make drivers slow down to less than 15 miles per hour. Recycled plastic, rubber, steel/metal, concrete, and asphalt are all common materials for driveway speed bumps. They have luminous studs or colored markings to help drivers see them at night or in bad weather. Their height might range between 25 and 100 mm. The driveway speed bumps should be at least 900 mm long.

FIGURE 2. 14 DRIVEWAY SPEED BUMP (SOURCE: SWAINE, 2023)

c. **Gravel road speed bumps**: Gravel roads have no extra surface material. The surface is usually covered in mud and gravel. As a result, when vehicles travels at high speeds on these types of roads, gravel and dirt will disperse and may cause difficulties for pedestrians or people living in the residence. Installing calming measures such as gravel road speed bumps, speed limit signs, stop signs, speed signs, road signs, warning signs, and other signage can help to alleviate these problems. Vehicles moving on loose gravel surface have longer braking distance, making it difficult for speeding vehicles to reduce their speed at the appropriate time. Speed bumps, on the other hand, can help lower speed for pedestrians and traffic safety. Gravel road speed bumps cannot be painted, and asphalt bumps wear out quickly on gravel roads. Specially constructed rubber or steel speed bumps with built-in reflectors are better suited for gravel roads. Gravel road speed bumps minimize traffic congestion by requiring vehicles to slow down to less than 15 mph, making the path safer for pedestrians using crossings or safety lanes.

FIGURE 2. 15 GRAVEL ROAD SPEED BUMP (SOURCE: RUBBERFORM, 2023)

d. **Earth road speed bumps:** The function of dirt road speed bumps is the same as gravel road speed bumps. The distinction is that they are utilized on earth roads rather than gravel ones. Dirt roads lack a good surface as well. Dirt distribution can also make it harder for residents living nearby to keep their homes clean. Installing dirt road speed bumps on dirt roads at areas where pedestrian traffic is heavy and dwellings are adjacent is an excellent way to prevent dirt dispersal. Speed bumps made of rubber, plastic, or steel that are specifically built for dirt roads will survive longer than asphalt or dirt speed bumps.

FIGURE 2. 16 EARTH ROAD SPEED BUMP (SOURCE: SAWADOGO, 2023)

e. **Garage speed bumps:** The safety of people in garages very importance. It is critical to set a speed limit in high-traffic areas when automobiles and pedestrians are close together. Garage speed bumps are an excellent technique to regulate traffic and keep vehicles moving safely through a garage. If bicycles, motorists, or other drivers in your garage have a habit of ignoring stop signs, parking signs, and traffic signs and markings, adding speed bumps in front of them can be an effective option to make drivers follow signs.

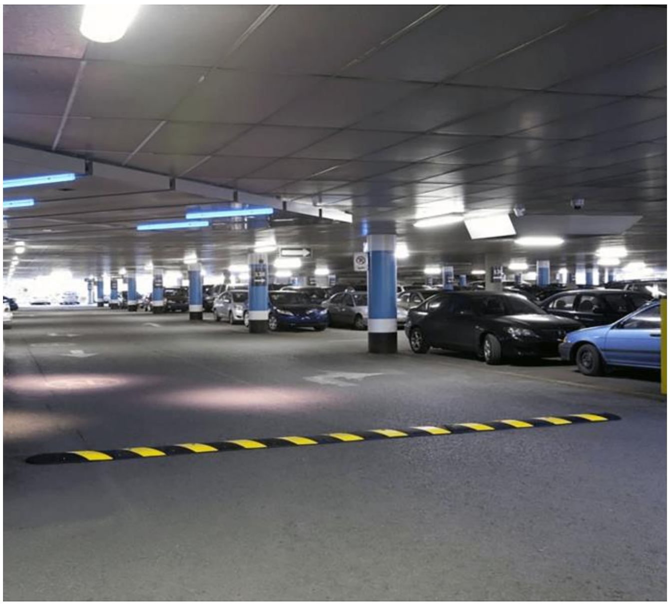

FIGURE 2. 17 GARAGE SPEED BUMP (SOURCE: NATIONAL TRAFFIC SIGNS, 2023)

f. **Parking lot speed bumps**: Parking lot speed bumps efficiently manage vehicle arrangement and speed in parking lots. Buses, vehicles, motorcycles, ambulances, and any other vehicle parked in a parking lot must adhere to a stated speed limit enforced by the parking lot owner using speed bumps. Parking lots are areas where automobiles and pedestrians can come into direct touch. As a result, it is critical that drivers maintain a reasonable pace for the protection of pedestrians. It will prevent parking lot accidents and may bring you more satisfied customers. Install speed bumps in high-traffic locations to make your on-street parking lot safer for automobiles and the general public. Reduce car accidents and vehicle-pedestrian collisions by using appropriate traffic control measures.

FIGURE 2. 18 PARKING LOT SPEED BUMP (SOURCE: CAMINO, 2023)

2.6 GEOMETRIC DESIGN OF SPEED BUMPS

The Transport and Road Research Board of Great Britain found in 1975 that the best design form for a speed hump was parabolic, and their specifications were 12 feet wide in the direction of movement, and four inches high. At the design speed or below the design speed of this bump, a driver will not experience discomfort, but above the design speed, drivers would experience increasing amounts of discomfort as speed increased. It was found that the average maximum speed was reduced by 30% due to the introduction of speed bumps (Clement, 1983).

In the United States, the ITE (Institute of Transportation Engineers) Traffic Engineering Council produced design standards based on the Watts speed hump profile (ITE Traffic Engineering Council, 1997). These recommendations proposed using a parabolic form 12 feet long with a height of three to four inches. Since 1993, experience in the United States has generally led to the deployment of 3.5-inch speed humps (Wainwright, 1998). This design typically yields an 85th percentile speed between 15 and 20 mph (Ewing, 1999). However, the Watts type hump has been modified in numerous jurisdictions. Portland, Oregon, for example, has created a 14-foot parabolic speed hump that is three inches high. The 85th percentile speed for the 14-foot parabolic speed hump is approximately 3 mph faster than the normal 12-foot Watts hump (Ewing, 1999). This 14-foot speed hump design has received national acceptability and is now utilized in a number of jurisdictions (Wainwright, 1998).

The Seminole County speed hump is another popular design shape in the United States. It has circular ramps that are six feet long. The hump is a 22-foot-long, three-to-four-inch-high flat-topped undulation. The design is also known as a speed table (Ewing, 1999; ITE Traffic Engineering Council, 1997).

Speed bumps can also be non-parabolic or trapezoidal in shape (i.e., sinusoidal or circular) which can be used in alongside other traffic calming devices such as chokers (Ewing, 1999; LaRosa, 2001; Transportation Association of Canada, 1998). Enhance speed humps, which combine a choker with a speed hump and result in both vertical and horizontal deflection, are regularly installed in Boca Raton, Florida, and Bellevue, Washington (LaRosa, 2001). Boca Raton's upgraded speed hump design includes a 22-foot-long four-inch speed table hump and a choker that reduces the roadway width to 18 feet (LaRosa, 2001).

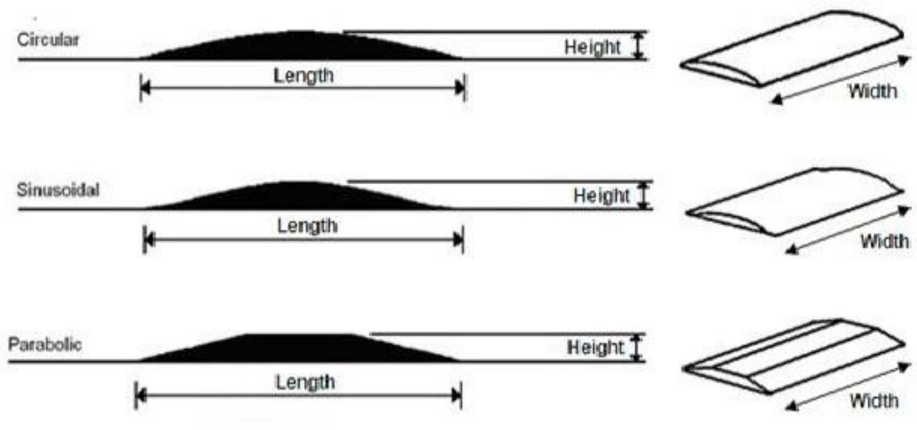

FIGURE 2. 19 COMMON SHAPES AND DIMENSIONS OF SPEED BUMPS

2.7 INSTALLATION OF SPEED BUMPS

2.7.1 RUBBER SPEED BUMPS

Rubber speed bumps may be preferred to asphalt for a variety of reasons, including their ease of installation and removal, reduced damage, and lower cost. A rubber speed bump might be quite simple to install, but it must be done properly to guarantee that it stays in place and endures.

1. Set up the speed bump in the desired location.

2. On the top of the hump, drill holes through the designated places. The size of your drill bit should be specified in your product to match the size of the spike or lead shield that will finally secure it in place.

3. To make sure the holes are deep enough, remove the bump and drill them again. Once more, the depth will vary depending on the type of bump you apply. After the holes are drilled, clean up the area of any trash. When utilizing bolts and shields, hammer the lead shields into the holes before reinstalling the speedbump. It could also be advised to use an adhesive to layer the product's bottom and fill any holes.

4. After repositioning the speed bump over the holes, fasten it there. If you're using spikes, you'll need to smash each one into position. At this point, if you're utilizing bolts and shields, you'll tighten the bolt into the shield. To ensure optimal use and little damage, make the speed bump as secure as you can. Each bolt can be tightly tightened with a ratchet.

FIGURE 2. 20 RUBBER SPEED BUMP (SOURCE: ALLSTATE, 2023)

2.7.2 ASPHALT SPEED BUMP

1. Layout and mark area for the placement of speed bumps
2. Clean the area of all dirt and debris
3. Key the existing pavement surface
4. Tack coat area of installation using liquid asphalt
5. Install hot mix surface asphalt to a maximum height of 3-1/2 inches, at the apex and a width of 18’’
6. Apply a seal of liquid asphalt to the adjoining edge of the installation to help prevent moisture penetration
7. Apply heavy duty reflective traffic plant sufficient enough to identify the speed bump (Lombardo, 2016).

FIGURE 2. 21 ASPHALT SPEED BUMP (SOURCE, EMPIRE, 2023)

2.8 METHODS OF SPEED BUMP DESIGN

1. Experimental design method: the ultimate objective of classical experimental design is to specify the best location for installing speed bumps before stop point. Montogomery (2008) provided guidelines for the design of speed bumps, in which the factors or input of the process are classified as either controllable or uncontrollable factors. The four controllable factors include; car speed before bump, number of passengers, surface inclination and distance from bumps to stop point.
2. Mixed Approach design: this approach is a methodology of research that advances the system to integration of quantitative and qualitative within a single investigation (Creswill, 2003)

2.9 CONSTRUCTION AND MAINTENANCE OF SPEED BUMPS

The majority of the time, speed bumps are built on already-existing roads. On brand-new roads, though, speed bumps might be built as part of resurfacing efforts. It is advised that jurisdictions considering installing speed bumps create standard building practices. By following these steps, it will be possible to build speed bumps that are more uniformly placed throughout the jurisdiction. Both municipal employees and private contractors hired to maintain municipal roads should follow the method.

A thorough working drawing illustrating the development of the intended profile and the permissible tolerance for speed bump height should be included in the building method. You can also give guidelines for building and material specs. Speed bumps should be maintained by the ministry of works (Parkhill et al., 2007).

2.10 REVIEW OF PREVIOUS RELATED STUDIES

2.10.1 PREVIOUS RELATED STUDIES ON SPEED REDUCING EFFECT OF SPEED BUMPS

Numerous studies on the usefulness of speed bumps in reducing crash rates and speed have been published in the literature on traffic safety. Some of these studies used vehicle speeds to assess the effects of speed bumps. For instance, Yaacob and Hamsa (2021) conducted a study to assess the effect of road hump on vehicle operating speed in Taman Setapak residential area in Kuala Lumpur (Malaysia). Using field observation and spot speed survey, data was collected on the roadway geometry and design characteristics of the humps, and vehicles speeds at different points near the humps. It was observed that design characteristics of the humps significantly contributed to speed reduction, with vehicle speed of about 30 km/h on approaching the humps and up to 10 km/h at the humps.

In Serbia, Antic et al. (2013) on their part, conducted a before-after study to evaluate the effect of speed bumps on vehicle operating speed at locations of high pedestrian presence, using varying heights (3, 5 and 7 cm) in Belgrade. Speed measurements were done a day before the installation of the bumps and a month afterwards. The 50th and 85th percentile speeds were determined, indicating significant reduction in speeds after the bumps installation. Based on the results, it was suggested that speed bumps height of 5 and 7 cm should be installed at locations where vulnerable road users are highly at risk. It is palpable that, speed humps have speed reducing effect.

In a recent study, Mohanty, (2021) investigated the effect of speed humps on vehicle operating speed. The study involved twelve (12) speed humps located on arterial roads in Bhubaneswar, a smart city in India. The study reported a reduction in vehicle approach speed from 33 km/h at 20 m to the speed hump and 9.8 km/h at the speed hump.

While some studies employed speed as the only performance measure for speed humps, others have employed both vehicle speed and crash data, to explore the link between speed reducing characteristics of humps and safety. Two separate studies in Ghana, reported significant reduction in speed and pedestrian crashes on selected calmed roads. Afukaar and Damsere-Derry (2010) evaluated the effectiveness of speed humps in reducing vehicle speeds and pedestrian crashes at selected settlements along the Kumasi-Konongo Highway, using a before-after study approach. Police reported crash data alongside measured vehicle speeds at six treated sites were collected before and after the installation. The installation of the speed humps accounted for an annual reduction in pedestrian casualties of 63%, and marked reduction in vehicles speeds ranging from 71 to 87 km/h before, and 32 to 36 km/h after installation. In a similar study, Damsere-Derry et al. (2019) examined the effects of traffic calming measures on vehicle speeds and pedestrian injury severity in 38 selected settlements, comprising 19 “with”, and 19 “without” traffic calming schemes, in Ghana. The study realized that, the proportion of vehicles exceeding the 50 km/h speed limit was 30% or less in settlements with traffic calming measures, with 60% or more speed limit violations in settlements without traffic calming measures. It was further revealed that, the odds of pedestrian fatality was approximately two-fold in settlements without traffic calming measures compared settlements with the safety measures.

Additionally, Yeo et al. (2020) examined the effects of speed humps on both vehicle speeds and pedestrian safety in South Korea. In the study, speeds of vehicles were recorded as they were driven along roadway sections with multiple speed humps. Pedestrian crash data along the entire roadway sections was also analyzed. Speed reduction was observed at 30 m upstream of the speed humps, with substantial reduction at the speed humps. The speed reduction was, however, not sustained with vehicles regaining their original speeds after traversing the speed humps. Substantial speed reduction of 18.4% and 24.0% were reported on local and arterial roads respectively, with fewer pedestrian crashes and less injury severities registered at the speed humps within the 30 m analysis zone.

The performance of speed humps have also been investigated in combination with a variety of traffic calming measures, such as chicanes and raised pedestrian crossings.

Gitelman et al. (2017) examined the impact of raised pedestrian crosswalks with preceding speed humps installed at none signalized midblock pedestrian crosswalks on urban arterial and collector roads in Israel. Using a before-after study technique, the speed pattern before and after the installation of the raised pedestrian were compared, resulting in an overall safety improvement of the pedestrian crossings with marked reduction in 85th speed percentile of vehicles up to 29 km/h, which was sustained with time.

Agerholm et al. (2017) evaluated the effects of speed humps and chicanes on vehicle speeds on urban streets, in a small town of Skørping in northern Denmark, using Global Navigation

Satellite System (GNSS) data loggers installed on vehicles travelling on such streets. A before-after analysis revealed that, while both speed humps and chicanes have considerable speed-reducing effect, speed humps have superior safety performance due to greater reduction in speed variation.

2.10.2 PREVIOUS RELATED STUDIES ON CRASH REDUCING EFFECTS OF SPEED BUMPS

Also, numerous accomplishments involving the effectiveness of speed bumps in decreasing crashes have been documented in the safety literature. These research have mostly concentrated on collisions involving pedestrians.

Tester et al. (2004) conducted a matched case-control over a five-year period among children at pediatric emergency department after a traffic crash, in Oakland, California, to evaluate the protective effectiveness of speed humps, in reducing child pedestrian injuries in residential neighborhoods. A multivariate conditional logistic regression analysis revealed that, speed humps are related with lower odds of children sustaining injuries within their neighborhoods and in front of their homes after a road traffic crash. In a similar study, Arbogast et al. (2018) conducted a before-after studies after the installation of speed humps around a middle school, in response to frequent crashes between child-and-adolescent pedestrians and motor vehicles within that vicinity. The analysis was done using crash data collected 2.5 years before and 2.5 years after the installation of the speed humps. The installation of the speed humps resulted in 37.5% reduction in pedestrian-involved crashes.

In a recent study, Shahdah and Azam (2021) evaluated the effect of speed humps on the safety and mobility of unconventional median U-turn. In the study, speed humps were placed at distances of 50 m and 20 m upstream from the U-turn intersections. VISSIM microscopic traffic simulation model was used to simulate and extract trajectories of vehicles. Surrogate safety assessment model (SSAM) was then applied to extract traffic conflicts based on the time to collision (TTC) surrogate safety measure. Delays and safety concerns were significantly observed at speed humps placed 20 m from the intersections compared with speed humps at the 50 m locations.

CHAPTER THREE

3.0 METHODOLOGY

3.1 STUDY AREA

The study area of this research work is focused on Osasogie community in Egor local government of Edo state, located in Zone 31N, between Latitude 6.3875°N to 6.3852°N and longitude 5.6190°E to 5.6169°E. The area is densely populated with 339,899 as at 2006 (NPC, 2006). There were 22 speed bumps in total, located along these roads and all these bumps were made of asphalt and have either convex or flat shapes with variable height and widths. The satellite imagery showing the study area is presented in Fig. 3.1.

FIGURE 3. 1 SATELLITE IMAGERY SHOWING OSASOGIE COMMUNITY (SOURCE: GOOGLE EARTH PRO)

This area was considered due to some reasons which includes:

1. Engineering designs of roads that contain design or implementation errors.
2. Failure to apply laws that compel drivers to abide by traffic regulations
3. The significant and sustained increase in the number of automobiles registered in the country in general over the past few years.

4. The spread of random speed bumps that are not subject to any engineering controls.

5. Absence of traffic lights and signs.

3.2 DATA COLLECTION TECHNIQUES

The study was carried out in two phases.

1. Field study
2. Questionnaires

3.2.1 FIELD STUDY

The first stage began with a reconnaissance survey of the area, which was done by an observation of the area, to get the basic information of the roads, such as the number of speed bumps in a street, the type of speed bumps that were installed, and the conditions of the speed bumps. A detailed road map of the Osasoge Metropolis was obtained, with the use of google earth. Thorough field survey was then conducted on different roads in the area, and the speed bumps cross sectional dimensions (i.e. height, length and width) was collected physically from these locations. A hand held GPS was used to collect the coordinates of the location of each speed bump on the road and then photographs of the devices were also taken. The following instruments were used on the field to obtain data:

a. **30 meters measuring tape**: The 30m measuring tape, was used to measure the length, and width of each speed bump, and then the clear spacing between one speed bump and the other.

FIGURE 3. 2 30 METERS MEASURING TAPE

b. **7.5m steel tape**: The 7.5m steel tape was used to get the height of speed bumps, which was measured from the pavement surface to the apex of the speed bump

FIGURE 3. 3 7.5M STEEL TAPE

c. **Hand held GPS receiver**: The GPS receiver that was used was the GARMIN GPSmap 78s. It was used to collect the GPS location of each existing speed bumps on the different streets in the study area. The GPS receiver was set to zone 31N with an accuracy of 3m and coordinates were in UTM (Universal Transverse Mercator) system.

FIGURE 3. 4 GARMIN GPSMAP 78S GPS RECEIVER

3.2.2 QUESTIONNAIRES

The next phase of the study was carried out with open ended questionnaires for the purpose of obtaining, information from drivers and residents in the selected streets. For the drivers, the questionnaire, sought for information on the effects of installed speed bumps, on their vehicles, whether these speed bumps causes an increase in fuel consumption, damage to the vehicle or wheel misbalancing. For the residents, the questionnaire sought to gather information, on the installed speed bumps, if they cause noise pollution, and if they improve the safety of the community. 50 questionnaires were distributed to respondents.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter focuses on the data acquired from the field study and questionnaires, and also the discussion of these data. Information on the speed bump location, and geometric properties were got from the field study, while information on the effect of speed bumps on vehicles and safety of inhabitants were got from the questionnaires

4.1 RESULTS

4.1.1 SPEED BUMP GPS COORDINATES

TABLE 4. 1: GPS COORDINATES OF SPEED BUMPS ON FGGC ROAD

FEDERAL GOVERNMENT GIRLS COLLEGE ROAD				
Speed bump number	Easting (mE)	Northing (mN)	Easting (mE)	Northing (mN)
1	790535	707088	790537	707082
2	790572	707095	790574	707089
3	790610	707105	790612	707098

TABLE 4. 2: GPS COORDINATES OF SPEED BUMPS ON DENTISTRY ROAD

DENTISTRY ROAD				
Speed bump number	Easting (mE)	Northing (mN)	Easting (mE)	Northing (mN)
1	790376	707181	790377	707178
2	790246	707150	790245	707155
3	790100	707120	790099	707124
4	789975	707093	789974	707097
5	789841	707064	789839	707070
6	789707	707035	789704	707043
7	789573	707006	789569	707016
8	789439	706977	789434	706989
9	789305	706948	789299	706962
10	789171	706930	789168	706937

TABLE 4. 3: GPS COORDINATES OF SPEED BUMPS ON HOSPITAL ROAD

HOSPITAL ROAD				
Speed bump number	Easting (mE)	Northing (mN)	Easting (mE)	Northing (mN)
1	789485	706981	789479	706983
2	789455	707053	789452	707055
3	789425	707125	789425	707127
4	789395	707197	789398	707199
5	789365	707269	789371	707271
6	789337	707340	789345	707342

TABLE 4. 4: GPS COORDINATES OF SPEED BUMPS ON UBTH STAFF SCHOOL ROAD

UBTH STAFF SCHOOL ROAD				
Speed bump number	Easting (mE)	Northing (mN)	Easting (mE)	Northing (mN)
1	789354	707375	789290	707372
2	789463	707405	789460	707407
3	789570	707436	789567	707441

WIDTH, HEIGHT AND LENGTH OF SPEED BUMPS

TABLE 4. 5: WIDTH, HEIGHT AND LENGTH, OF SPEED BUMPS ON FGGC ROAD

FEDERAL GOVERNMENT GIRLS COLLEGE ROAD						
Speed bump number	width of speed bump (m)	Standard width (m)	height of speed bump (m)	Standard height (m)	Length of speed bump (m)	Standard length (m)
1	0.7	0.6 - 1.2	0.07	0.07 - 0.10	4.5	3.65 – 5
2	0.92	0.6 - 1.2	0.085	0.07 - 0.10	5.6	3.65 – 5
3	0.92	0.6 - 1.2	0.051	0.07 - 0.10	6.3	3.65 – 5

TABLE 4. 6: WIDTH, HEIGHT AND LENGTH, OF SPEED BUMPS ON DENTISTRY ROAD

DENTISTRY ROAD						
Speed bump number	width of speed bump (m)	Standard width (m)	height of speed bump (m)	Standard height (m)	Length of speed bump (m)	Standard length (m)
1	0.75	0.6 - 1.2	0.05	0.07 - 0.10	4.85	3.65 – 5
2	0.55	0.6 - 1.2	0.07	0.07 - 0.10	5	3.65 – 5
3	0.7	0.6 - 1.2	0.06	0.07 - 0.10	3.46	3.65 – 5
4	0.68	0.6 - 1.2	0.08	0.07 - 0.10	4.76	3.65 – 5
5	0.6	0.6 - 1.2	0.06	0.07 - 0.10	5.38	3.65 – 5
6	0.72	0.6 - 1.2	0.08	0.07 - 0.10	5.71	3.65 – 5
7	0.63	0.6 - 1.2	0.072	0.07 - 0.10	4.82	3.65 – 5
8	0.54	0.6 - 1.2	0.057	0.07 - 0.10	6.1	3.65 – 5
9	0.52	0.6 - 1.2	0.068	0.07 - 0.10	5.65	3.65 – 5
10	0.65	0.6 - 1.2	0.075	0.07 - 0.10	4.8	3.65 - 5

TABLE 4. 7: WIDTH, HEIGHT AND LENGTH, OF SPEED BUMPS ON HOSPITAL ROAD

HOSPITAL ROAD						
Speed bump number	width of speed bump (m)	Standard width (m)	height of speed bump (m)	Standard height (m)	Length of speed bump (m)	Standard length (m)
1	0.64	0.6 - 1.2	0.035	0.07 - 0.10	6.84	3.65 - 5
2	0.68	0.6 - 1.2	0.036	0.07 - 0.10	6.92	3.65 - 5
3	0.76	0.6 - 1.2	0.043	0.07 - 0.10	7.52	3.65 - 5
4	0.86	0.6 - 1.2	0.045	0.07 - 0.10	7.38	3.65 - 5
5	0.7	0.6 - 1.2	0.035	0.07 - 0.10	7.5	3.65 - 5
6	0.65	0.6 - 1.2	0.04	0.07 - 0.10	7.25	3.65 - 5

TABLE 4. 8: WIDTH, HEIGHT AND LENGTH, OF SPEED BUMPS ON UBTH STAFF SCHOOL ROAD

UBTH STAFF SCHOOL ROAD						
Speed bump number	width of speed bump (m)	Standard width (m)	height of speed bump (m)	Standard height (m)	Length of speed bump (m)	Standard length (m)
1	0.56	0.6 - 1.2	0.075	0.07 - 0.10	5.25	3.65 - 5
2	0.68	0.6 - 1.2	0.084	0.07 - 0.10	4.43	3.65 - 5
3	0.64	0.6 - 1.2	0.068	0.07 - 0.10	4.28	3.65 - 5

3.1.1 SPACING OF SPEED BUMPS

TABLE 4. 9: SPEED BUMP SPACING ON FGGC ROAD

FEDERAL GOVERNMENT GIRLS COLLEGE ROAD		
Spacing	Distance (m)	Standard distance (m)
1-2	37.8	40 - 120
2-3	39.6	40 - 120

TABLE 4. 10: SPEED BUMP SPACING ON DENTISTRY ROAD

DENTISTRY ROAD		
Spacing	Distance (m)	Standard distance (m)
1-2	151.73	40 – 120
2-3	159.15	40 – 120
3-4	152.46	40 – 120
4-5	154.83	40 – 120
5-6	156.72	40 – 120
6-7	153.12	40 – 120
7-8	154.68	40 – 120
8-9	159.33	40 – 120
9-10	152.75	40 – 120

TABLE 4. 11: SPEED BUMP SPACING ON HOSPITAL ROAD

HOSPITAL ROAD		
Spacing	Distance (m)	Standard distance (m)
1-2	126.44	40 – 120
2-3	137.73	40 – 120
3-4	143.6	40 – 120
4-5	139.3	40 – 120
5-6	127.8	40 – 120

TABLE 4. 12: SPEED BUMP SPACING ON UBTH STAFF SCHOOL ROAD

UBTH STAFF SCHOOL ROAD		
Spacing	Distance (m)	Standard distance (m)
1-2	128.56	40 – 120
2-3	134.45	40 – 120

4.1.2 RESULTS OBTAINED FROM THE USE OF QUESTIONNAIRE BY FREQUENCY

In this category, 50 questionnaires were distributed to respondents to get information on the effect of speed bumps on vehicles and on the safety of residents. These were the following results, as seen in Fig. 4.1, Fig. 4.2, Fig. 4.3, and Fig. 4.4.

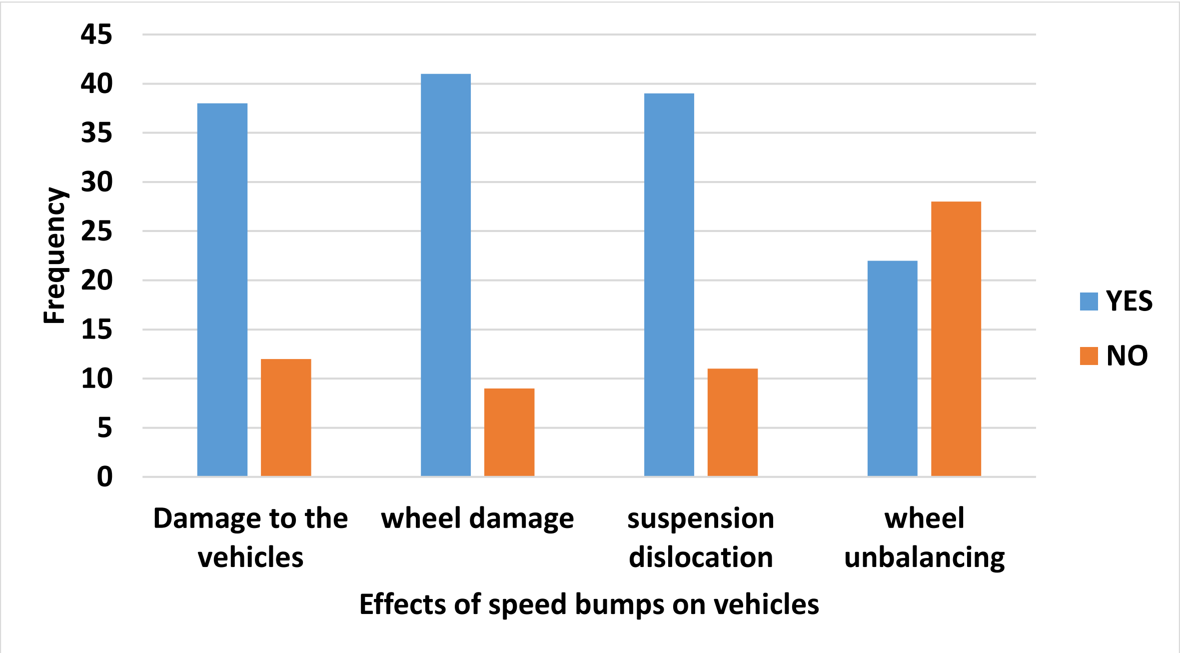

FIGURE 4. 1 EFFECTS OF SPEED BUMPS ON VEHICLES

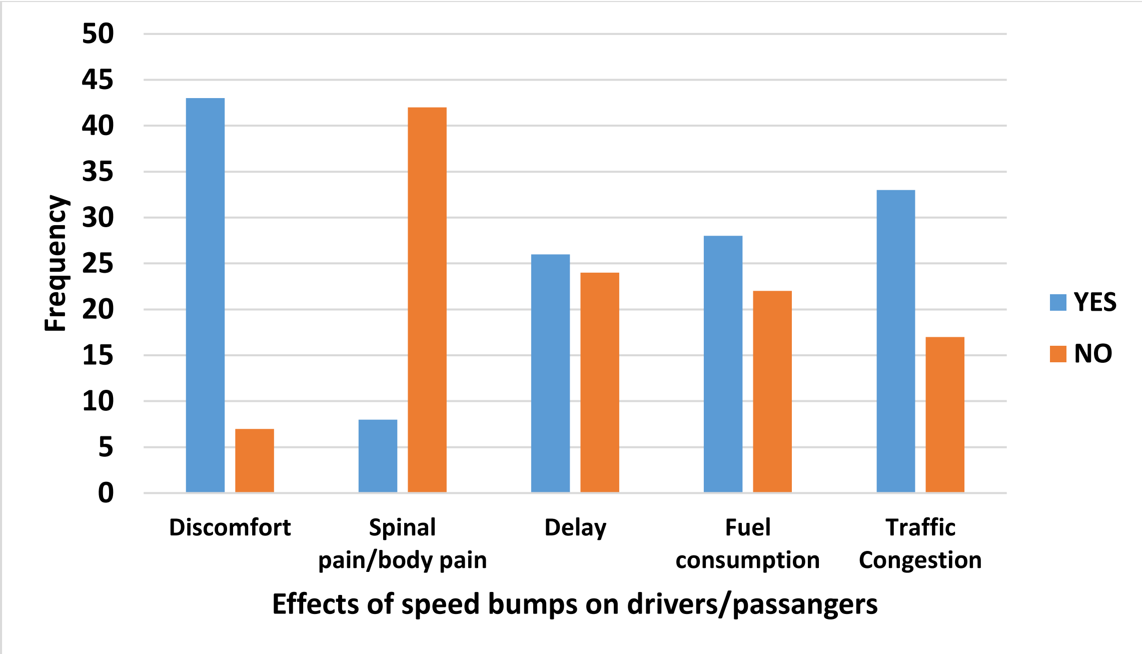

FIGURE 4. 2 EFFECTS OF SPEED BUMPS ON DRIVERS/PASSENGERS

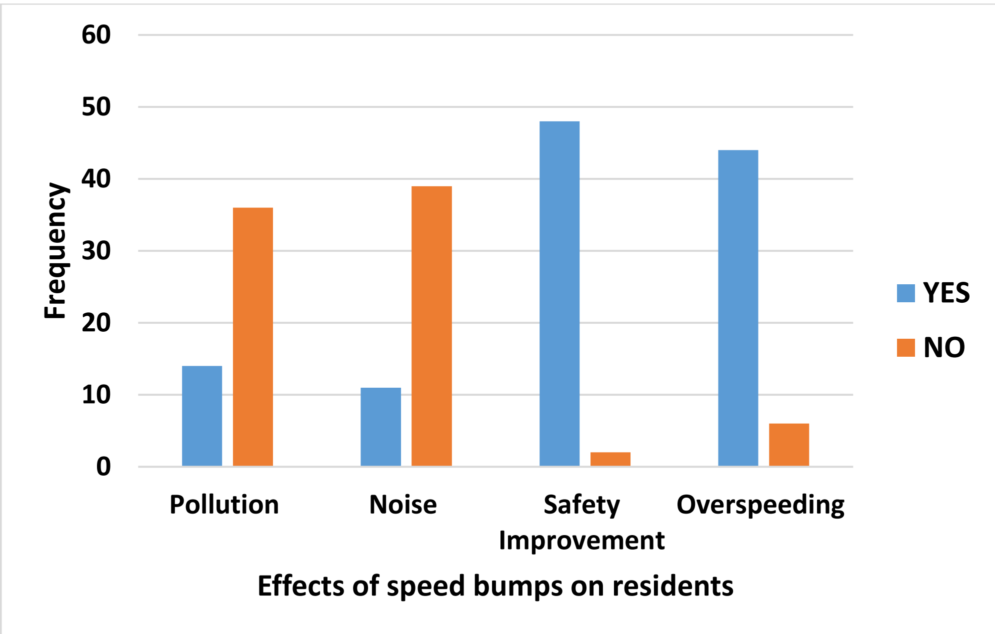

FIGURE 4. 3 EFFECTS OF SPEED BUMPS ON RESIDENTS

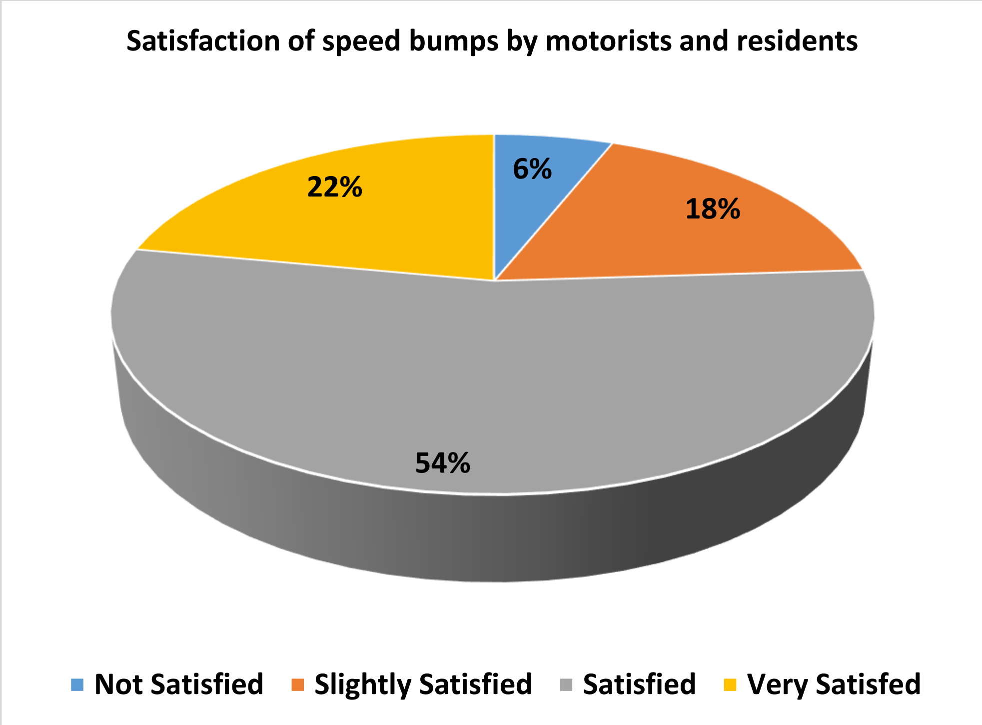

FIGURE 4. 4 SATISFACTION OF SPEED BUMPS BY MOTORISTS AND RESIDENTS

4.2 DISCUSSION OF RESULTS

It was first observed from the reconnaissance survey that all the speed bumps were constructed with asphalt. In total, 22 speed bumps were studied and analyzed of which 3 were located at Federal Girls Road, 10 at Dentistry road, 6 at Hospital road and 3 at UBTH staff school road.

From the field survey, the geometric properties of the speed bumps were collected, as seen in Table 4.5 to Table 4.12, and compared with the Federal Heights Municipal Code, of Colorado, USA. From table 4.5, it can be seen that only speed bump 1 at Federal Girls Road, was found to be in accordance with the code. Also, from table 4.6, speed bump 4, 7, and 10 at Dentistry Road were also found to be in accordance with the code, while no speed bump at Hospital road and UBTH staff school road, met the design criteria for the Federal Heights Municipal Code, of Colorado, USA, as seen in table 4.7 and table 4.8.

Only 4 speed bumps, therefore met the design criteria which is 18.18% of the entire speed bump in the study area.

Finally, the spacing of all the bumps, did not meet the design criteria, as they were either too close to each other, or too far apart.

From questionnaire survey, it was found that there are a vast variations in the response from the point of view of respondents. For the question which deals with the satisfaction of speed bumps in the area, a general assessment of satisfaction of the speed bump by motorist and residents were taken on a scale of 1-10 of which 1-2 represented not satisfied, 3-5 represented slightly satisfied, 6-8 represent satisfied and 9-10 represented very satisfied. It can be seen from figure 4.4, that 6% of respondents were not satisfied, 18% were slightly satisfied, 54% were satisfied and 22% were very satisfied.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The usage of speed bumps on the Osasogie area has been assessed and evaluated, because of the excessive speeding and the existence of road intersections, based on the findings and the information that has been offered in previous chapters.

It is not in doubt that speed bumps play a significant role in the reduction of vehicular speed, however, most of the speed bumps, located in the Osasogie area, were illegally installed, and from the results gotten from the field survey, they were reported not to have met the standard requirements of the Federal Heights municipal code of Colorado, USA.

It was found that the ideal material used for construction, was asphalt, as no other material was used in the construction, of the bumps.

The application of speed bumps, with height of 0.07m - 0.10m, width of 0.6 m- 1.2m and interval spacing of 40m – 120m can be used to achieve a speed limit of 40km/hr, based on a model of the standard speed bump, for the chosen area.

This study focuses solely on the assessment of speed bump as a traffic calming device and did not put into consideration, the pavement conditions. For further studies, the pavement conditions, can be studied alongside with the speed bump on the effect of vehicular speed

5.2 RECOMMENDATION

There is no established application procedure for the implementation of traffic calming, according to a conversation with the road administration. Therefore, a standard method is required in order to establish a standard, efficient, and effective implementation.

Some recommendations can be made to improve the implementation based on the results of the field survey and the users' feedback. Some of these recommendations include;

1. Redesign and reconstruct any existing bumps that are lower than 0.07m or greater than 0.10m in height.

2. In order to increase efficacy and uniformity, bumps with widths greater than 1.2 meters and less than 0.6 meters should be rebuilt.

3. Roads should be marked with traffic sign and symbols to keep drivers and motorists aware on what to expect when driving.

4. The federal road safety commission and the government should promote understanding of traffic laws and regulations, by creating public awareness.

5. There should be sanctions for those who violate traffic laws.

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