

EVALUATION OF SPEED BUMPS ALONG WARRI-SAPELE

ROAD

WARRI, DELTA STATE

BY

ATSAGBEDE, Demas Oma

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**A PROJECT REPORT SUMMITTED TO THE DEPARTMENT OF
CIVIL ENGINEERING IN PARTIAL FULFILLMENT FOR THE
AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING
(B.ENG.) IN CIVIL ENGINEERING.**

JULY 2021

CERTIFICATION

This is to certify that this project work was carried out by Atsagbede, Demas Oma, Matriculation number ENG1406911 of the Department Of Civil Engineering, University Of Benin, Benin city Nigeria.

Engr. Igene Morris

Project Supervisor

Date

Engr. Dr. S.O. Iyeke

Head of Department

Date

DEDICATION

This project is dedicated to God Almighty, my lovely father who just joined his ancestors and to all individuals who may find it useful.

ACKNOWLEDGEMENT

I wish to express my profound gratitude to my project supervisor, Engr Igene Morris, for his help, support and the unparalleled knowledge and discipline that he instilled in me in the course of this project.

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Of no less importance are my friends namely, Bright, Franklin, Gandhi, Balogun, Emmix, Azeez, Kaycee, Kparobor, Edith and other course mates, whose infectious smiles, words of encouragement and memories will remain evergreen

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ABSTRACT

Driving in urban centers and neighborhoods at high speed without regard to safety of the inhabitants brought about the emergence of the use of speed bumps and other traffic devices. Road bumps play a crucial role in enforcing speed limits, thereby preventing over speeding of vehicles.

The use of this device overtime had resulted in series of debate worldwide. While some are complaining of the inconvenience caused by this device, others are calling for more of this device. This study therefore seek to investigate the use of speed bumps on Nigeria highway with specific reference to Warri-Sapele road, Warri, Delta State.

Using quantitative research method, 50 units of questionnaires were designed and administered to drivers, motorist and residents at various reference points on the road section to sought information about the effectiveness of the devices. Measurement of the height, width, length and spacing of the device were carried out with the aid of equipment in Geomatics Engineering and this data were compared to the city of Bakersfield, California standard for speed bump parameter.

The result shows that 84.4% of the existing speed bumps were of spacing below the LATM standard of 60-90(m), 26.7% had width less than the accepted value of 300mm and 100% had height exceeding the standard of 60mm. The result of the speed bumps parameters shows that the bumps were built with no recourse to specification as the height, width, length and spacing keeps changing from one bump to the other due to its instantaneous demand.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Transportation is vital to man's progress, growth, and wealth from the dawn of time (Badejo, 2011). During the primordial period, trekking, walking, and human portage were the most common forms of transportation, whereas early civilization's usage of beasts of burden and carts was replaced by automobiles. Urbanization and industrialisation, combined with an increase in the number of automobiles on the road, have resulted in more wealth and improved social economic initiatives, particularly for city people (Okoko, 2006).

The road sector is becoming increasingly dominant as cities grow in size and number (Badejo, 2014). It is undeniable that Nigeria is becoming increasingly urbanized, with an unparalleled increase in automobile ownership. As transportation is both a maker and a breaker of cities (Ogunsanya, 2002), high-speed driving in urban centers and neighborhoods without concern for the safety of the residents has become a typical occurrence. Many state capitals, urban centers such as Ibadan, Lagos, Akure, Osogbo, and medium-sized settlements such as Ife, Ijebu-Ode, and Owo etc. are in this situation (Alabi et al., 2013).

Uncontrolled urbanization and the lack of an effective public transportation system contribute significantly to urban dwellers' vulnerability to a variety of risks associated with fast moving vehicles in urban centers and neighborhoods, and significantly

increase the vulnerability of pedestrians, cyclists, children, the elderly, and the physically challenged within our neighborhoods in particular and across a variety of settings.

In addition to government efforts, residents and communities around the world have invented a variety of measures to improve their safety and dissuade fast moving vehicles from speeding on city streets. The usage of speed bumps on neighboring roadways is one of these efforts. Since the Transport and Road Research Laboratory of Great Britain introduced speed bumps in the early 1970s (Parkhill et al., 2007), various countries in both developed and developing countries have embraced its use as a traffic calming instrument. As a result, speed bumps play an increasingly important role in the enforcement of speed restrictions (Oke et al., 2007b), contributing to the improvement of pedestrian safety. Therefore, speed bumps were designed to break vehicular speeds in order to reduce the number of road accidents caused by speeding and to keep speed limits in particular defined places.

With the prediction that, despite various frameworks in place, road traffic injuries will rank third among causes of disability-adjusted life years in 2020 (Lagarde, 2007), the use of speed bumps in reducing road traffic injuries on Nigerian roads, particularly in neighborhoods and other settlements, must be investigated. The perceived unregulated way in which speed bumps are installed on roads in neighborhoods and other urban settlements throughout the country also demands immediate attention. Speed bumps must be carefully thought, planned, and logically constructed in order to be effective in reducing the rising burden of road traffic injuries in Nigerian cities.

The dotting of various metropolitan centers and other locations necessitates careful examination to determine their efficiency in improving the safety of inhabitants, pedestrians, and the vulnerable population in general. This study evaluated the location and deployment of speed breakers in Nigerian cities in light of this assumption.

1.2. Statement of the problem

Speed bumps have been shown in numerous studies to effectively reduce traffic speeds and/or volumes. The majority of investigations, however, were undertaken on a small number of roadways. As a result, the efficiency of speed bumps on the majority of highways across the country has not been fully assessed. Depending on the volume of traffic, speed bumps may work differently on broader and smaller roadways. People may have different levels of approval for traffic calming devices. Furthermore, a general lack of driver expertise with speed bump devices may have an impact on their ability to reduce speed (Beckman and Kush, 2000).

Some speed bumps were created illegally by people who live near roadways or by communities that surround highways. All of these bumps were built without regard for the characteristics of the vehicles that used the roads; their spacing was inconsistent; their height and width varied; and, to summarize, the bumps had no recourse to specification (Bukar, 2011).

The use of speed bumps as a conventional traffic calming device is progressively increasing as various traffic calming strategies continue to be adopted throughout Nigeria. Speed bumps, on the other hand, have been a source of debate in the field of traffic engineering globally. Some adhere to the ideology of its abolition, while others

have a different viewpoint. According to (Cowen, 2017) of Newsday, a recent report from the United Kingdom suggesting that the country remove speed bumps from its roads to ease vehicle passage and limit carbon emissions has sparked a heated debate in the United States, where homeowners often push for more speed bumps in their neighborhoods to slow drivers and thus save lives, while others complain of the clogged roads.

Before deciding whether or not these actions should be encouraged, an investigation of the speed bumps that have been erected on the highway must be conducted.

1.3 Aim and objectives.

The aim of the study is to investigate the effect of the constructed road bumps on the highway, using a section of Warri-Sapele road, Warri Delta State, Nigeria.

The objectives of the study are to:

- I. Determine the relevance of speed bumps at the designated location.
- II. Determine the speed bumps' appropriateness in compliance with international standards at the designated location.
- III. Assess the combined effect of the speed bumps on vehicles and drivers.
- IV. Ascertain the importance of speed bumps towards the safety of inhabitants.
- V. Model a standard speed bump for the case study area.

1.4 Scope of study

This study was carried out using a section of Warri-Sapele road from the Main market towards Warri-South local government secretariat Warri Delta State, Nigeria. The activities covered were measurement of height, length, width, spacing and modeling of a standard speed bump. Values were taken by direct measurement and questionnaires were distributed to seek information on the road bumps effectiveness and effects to both drivers, passengers and pedestrians.

1.5 Justification of the study.

A transportation engineer creates or improves transportation systems to provide safe and efficient traffic flow on roads, planes, trains, ships, buses, and other modes of transportation (Environmental science, 2016). Highways, airports, trains, bridges, and other transportation systems and infrastructures are among the things that transport engineers work on. They do it by analyzing data, identifying problems, and coming up with creative solutions to solve them (Environmental science, 2016). The gathering and evaluation of systems, traffic flow, accidents, expenses, and other statistics is often required to solve these complicated challenges.

It is critical to research the use of speed bumps in other similar locations before deciding whether or not to remove or place them in a particular site. On this foundation, this study will look into the use of speed bumps on the Warri-Sapele road in Warri City to discover if the planned results that led to their implementation were accomplished, or if unexpected problems arose. The result from this research work will prove evident if the current practice of installing speed bumps in densely populated urban centers should

be encouraged or abolished. If the installation of speed bumps caused safety or traffic operations concern, mitigation measures, such as the removal of the bumps, can be considered.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of road bump

Road bumps are raised sections of pavement that run the length of or partially across a roadway, causing cars to slow down in order to avoid the unpleasant bumping or vibrating sensation that occurs when driving through them (Parkhill et al., 2007). Speed bumps are a type of traffic calming device that uses vertical deflection to slow down motor vehicle traffic and enhance safety conditions. Vertical deflection devices are widely used around the world, and they're most frequent in areas where vehicle speeds are restricted, usually to 40 km/h or 8-16 km/h in parking lots (Afukaa, 2001b).

Although speed bumps are efficient at slowing down vehicles, their use is occasionally contentious because they can increase engine noise and harm vehicles if driven at high speeds. Poorly designed speed bumps (often found in private car parks) can be distracting for drivers and may be difficult to navigate for vehicles with low ground clearance, even at low speeds. Many sport cars have this problem with speed bumps. Motorcyclists and bicyclists can be seriously injured by speed bumps if they are not readily visible (Alabi et al, 2013).

2.2. Composition

Asphalt, concrete, recycled plastic, metal, and vulcanized rubber are some of the materials used to make road bumps. When choosing a material for a new speed cushion, there are several trade-offs to consider.

Most vertical deflection devices have traditionally been made of asphalt or concrete.

These materials have higher permanency and are more effective at reducing traffic because of their rigidity and endurance. However, shaping and turning them into regular forms and precise dimensions can be difficult. Rubber items can be pre-shaped, and pre-formed rubber products are usually fastened down to make installation and removal easier. Temporary bolt-down installation is useful for planners who want to evaluate the use and placement of speed bumps before incorporating them into a larger project (Hallmark et al., 200

2.3 History of road bumps

The New York Times reported on an early application of what could be deemed speed bumps in the United States town of Chattam, New Jersey, which planned to raise its crosswalks five inches above the road surface on June 7, 1906. "A number of municipalities have explored this plan to reduce automobile speeding, but Chattam was the first to put it into action." At the period, the average car's top speed was roughly 30 miles per hour (48 kilometers per hour).

Athur Holly Compton was a scientist who won the Nobel Prize in physics in 1927 for his discoveries that revolutionized electromagnetic theory. He is most known for his work on the x-ray Compton effect. In 1953, he also devised "traffic control bumps," the basic concept for the speed bump. After witnessing the speed at which automobiles passed Brooklyn's hall at Washington University in St. Louis, Missouri, where he was chancellor, Compton began designing the speed bumps (Compton, 1953).

In 1973, the British Transport and Road Research Laboratory released a comprehensive research that looked at vehicle behavior for a wide range of bump geometry. Speed

bumps were not allowed on public highways at the time, but they had been erected on private roads. The first speed bump in Europe was built in 1970 in the Dutch city of Delft, according to a publication by the Institute of Transportation Engineers (ITE, 1970).

2..4 History of traffic calming device

The origins of traffic calming appear to be in traffic control measures implemented mostly in Germany and the Netherlands. According to Hass-Klau et al. (1992), Germany contributed to the development of traffic calming concepts by increasing pedestrianization in town centers, emancipating residents' associations, and raising public awareness of environmental issues. In turn, urban planners and traffic engineers in the Netherlands developed the notion "who discovered that people's well-being was influenced not just by housing but also by the surrounding streets" (Hass-Klau, 1990). According to Hass-Klau (1992), the central European traffic calming idea has always been ambiguous. As a result, tracing its origins is challenging. However, according to the same source (1990a), its policy can be traced back to three distinct roots:

- Colin Buchanan popularized the concept of environmental regions in his 1963 book "Traffic in Towns." In numerous British towns in the late 1960s, the first examples of what we now call traffic calming measures were erected in environmental zones;

- The new design, dubbed Woonerf (residential yards) by Dutch designers, emphasizes avoiding the traditional boundary between highway and pavement. All road users were blended and given equal rights on the surface produced. The maximum speed of a motor vehicle was limited to walking speed. It serves as a residence, a

gathering spot, a playground, and a strolling area. This public space also serves as a traffic conduit, but not for through traffic; and pedestrianisation initiatives, which often entail the closing of existing roadways to traffic, followed by paving, tree planting, and street furniture. Cyclists were not permitted in the initial systems used in city center streets, and service vehicles had limited rear access. Recently, pedestrianisation has been extended to local shopping streets, and diverse uses and functions such as service vehicles, bikes, and public transportation have been combined with pedestrians both there and in city centers.

"The confluence of these three principles had a significant impact on how traffic calming has been understood and implemented" in Europe, according to Hass-Klau. Due to the high expenses of implementation, some of those ideas, particularly those addressing Woonerf, have undergone some alterations and changes. "The 30 km/h speed-limit zones, first adopted in the Netherlands in 1983, were considered as a cheaper and more effective choice than Woonerven, because wide areas could be treated for the same amount of money and with equal results," Hass-Klau et al (1992) write.

When comparing what various writers have written under the heading of environmental traffic management (e.g. Keller (1986), Bowers (1986), Monheim (1986), Nielsen and Rassen (1986), Monheim (1986), and Russell (1988), the connection to traffic calming objectives and strategies is obvious. The installation of pedestrianized areas appears to be the first sign of environmental traffic management. However, in many Central European countries, the evolution of this concept followed distinct paths.

In Germany, the conceptual and practical development of environmental traffic management began with the implementation of large-scale pedestrianization programs. Residents' organizations played a critical role in raising awareness about the need to protect pedestrians and residents from increased motor traffic, resisting new road proposals, and demanding traffic flow reductions in residential neighborhoods. The increased public awareness of environmental issues also aided residents' associations. As a result, new solutions for residential areas and residential streets were sought. Improvements became a component of the overall urban regeneration effort in order to achieve livable streets, giving equal rights to pedestrians, children, cyclists and public transport users. To this end, traffic management restraint measures have been applied to residential areas using a variety of different treatments (Hass-Klau, 1990). The German version of environmental traffic management could be seen as a mixture of the theoretical British concept of environmental areas and the Dutch Woonerfs (Hass-Klau, 1986a).

The Dutch Woonerf is credited with starting environmental traffic management in Denmark. The term 'environmental traffic management', on the other hand, does not accurately capture the vast range of reasons served by traffic management schemes and traffic limitation measures used in Denmark. Environmental traffic calming in residential areas, city centers, and more recently on main roads is much more extensive than the British experience, with 'rest and play areas' subjected to regulations similar to Woonerf and the Danish '30 km/h quiet areas' with a minimum of regulations and a more realistic speed limit. For example, Hass-Klau et al (1992) commented that "a large

project on traffic calming in British town centres started 12 years later than the German equivalent and 16 years behind the Dutch version". However, the last five years have seen the extensive adoption of traffic calming in Britain.

The Woonerf, which was invented in the Netherlands in 1975 and has been widely adopted in Dutch towns and cities, is the most well-known Dutch contribution to urban environmental traffic management. Shopping centers and villages have also been subjected to traffic restrictions, and Woonerf rules were expected to be expanded to encompass these regions (Kraay, 1986).

2.5. Speed management

Speed management can be defined as a set of measures to limit the negative effects of excessive and inappropriate speeds in the transport system.

Taking into consideration the extent of speeding in most countries, and the impacts of speeding, there is little doubt that effective speed management is needed. It is generally recognised that an integrated and comprehensive approach to speed management is likely to be one of the best ways to improve on the current situation.

The employment of physical devices, street scaping treatments, and other measures (including rules and other non-physical measures) to influence vehicle activity in order to produce safer and more livable local streets is referred to as LATM (Austroads, 2004).

LATM is Concerned with the planning and management of road space utilization within a local traffic area following the modification of streets and street networks that were originally designed in ways that are no longer regarded appropriate for the demands of

residents and users of the local region.

2.6. Speed bump application

Streets are classified according to the type of service they generally provide. Arterial streets

are used for mobility purposes and are typically used by vehicles (on longer trips) at higher speeds. On arterial streets, such as highways and major urban streets, speed bumps are typically considered impractical because these roadways are meant to serve a mobility purpose. Collector roadways typically link arterials to the local roadway system. They normally experience moderate to low speeds. In most cases, speed bumps are not advised for collector streets, however they may be permitted in select areas. After an engineering analysis of the route, the decision to install a speed bump on a collector street is usually taken case by case. Local streets are designed to service a small number of low-speed vehicle excursions and are primarily used to offer access to land uses. On these types of roads, speed bumps are employed when the community and city believe that reduced vehicle speeds and/or through traffic are required, and this belief is backed up by engineering findings.

Other elements should be addressed before installing (or designing) a speed bumps, in addition to the type of roadway. Emergency vehicles must be able to clear and respond to an emergency along a route in a timely manner. According to studies, each speed bumps increases (depending on the vehicle type) the response time of emergency vehicles. One reason some communities prohibit the construction of speed bumps along designated emergency vehicle response routes is because of this. Signs and/or

pavement markings must accompany the placement of speed humps to alert motorists to their presence and to indicate appropriate driving behavior.

2.7. Factors that determine the use of speed bumps

When deciding whether or not to build speed bumps in a specific place, numerous criteria are taken into account.

Vehicle speeds are normally reduced to around 10 to 15 miles per hour when speed bumps are used on some local roads and other low-speed roadways. Speed bumps may be used on local streets when it is determined that lower vehicle speeds and less through traffic are needed. Speed bumps are not used on roadways intended for high-speed and high-volume traffic.

2.8. The operation of speed bumps

A speed bump works by transferring an upward force to the vehicle, and its occupants as it crosses the bump. The force produces a front-to-back pitching acceleration in vehicles having a wheelbase similar to the length of the bump that increases as the vehicle travels faster (Weber et al 2000). At low speed the acceleration is of small amplitude, as speed increases the amplitude and pitching also increase, as does the displacement. At low speeds, the speed bump gently lifts and pitches the vehicle, only as speed increases do the accelerations become apparent as a jolt to the vehicle and its occupants (Weber et al., 2000).

2.9. Speed bump parameters

Several geometric and layout design parameters can be used to fully define speed bumps. Length, height, profile, spacing, and width are the geometric design parameters.

Speed bump spacing and kind of materials, as well as marking and signage, are all design parameters.

I. Length

The length of a speed bump is the most essential geometric design parameter. To separate the effects of approaching and exiting the bumps for these vehicles, effective speed bumps should be at least as long as the wheelbase of the vehicle. If larger vehicles are expected, longer speed bumps should be used. Experiments have demonstrated that as lengths get longer, peak accelerations occur at faster rates and more linear dynamic effects emerge. Longer bumps, on average, have superior properties for reducing speed. Longer bumps may be more suitable for big vehicles, though upper limits have yet to be determined (Pau, 2002).

In Denmark, circular bumps up to 9.5m long are used to reduce speeds to 50km/hr for automobile and 35km/hr for buses (Vejdirektoratet, 1991). Trapezoidal bumps as much as 12m long are used in Netherland and Australia (Hass-klau et al., 1992). In Britian, Columbia, speed bump is considered adequate for design of 30km/hr (Livamagi, 1995).

II. Height

The magnitudes of vertical accelerations and the maximum levels of reported discomfort can be influenced by the height of speed bumps (Kassem and Alnassar, 1981). As vehicles exit the measures, high bumps may cause damage to their undercarriages. Low bumps aren't always effective. The average height is between 30mm and 100mm (Pau,2002).

III. Width

Speed bumps can run the length of the road or stop just short of the curb or road edge. The latter solution has the advantage of not affecting drainage at the curb and gutter, as well as being less expensive to install in an urban setting. Unless precautions are made, drivers may try to take advantage of narrower widths and maneuver around bumps (Webster, 1995). The width ranges from 600mm to 1200mm in most cases.

IV. Profile

The impacts of speed bump shape, and especially altering the slopes of the entry and departure ramps have not been studied as completely as the effects of length and height. The best ramp slopes for various speed bump designs, notably trapezoidal bumps, are still being researched (Jarvis, 1992).

Although the Dutch consider sinusoidal speed bumps to have the best dynamic properties at higher speeds, circular, trapezoidal, and sinusoidal speed bumps of identical diameters have been proven to operate nearly equally well (Pau,2002).

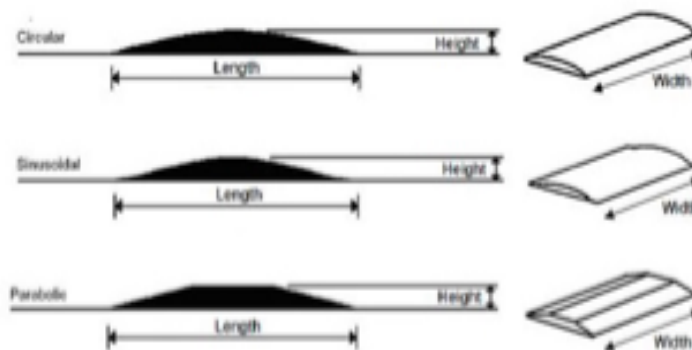


fig. 2.1 Speed bumps profile (Weber 1998)

V. Spacing

High bump crossing speeds, as well as a big distance between them, can result in high speeds between bumps. The layout design or spacing of speed bumps is a critical issue to consider because one of the goals of traffic calming is to reduce vehicle speed throughout entire streets. According to previous study from numerous countries, speed bumps should be spaced between 40 and 60m apart to attain overall speeds of 25 to 30km/h. For a 50km/h pace, a greater distance of up to 100m can be used. With the addition of additional traffic calming measures, the spacing between bumps can be increased (Pau, 2002).

2.10. Materials, Signage, and Marking

Temporary speed bumps are usually composed of recycled rubber, while permanent speed bumps are usually built of concrete or asphalt. Unlike permanent devices, temporary devices are anchored into the existing pavement rather than being erected as an integrated component of the roadway. The temporary devices were met with a variety of reactions. Because of a 0.75-inch lip on the temporary speed hump, which they felt impaired performance, city officials in Fargo did not believe that temporary hump consequences were reflective of permanent devices. Due to vehicle movement and temperature changes, Concord officials had issues with the shape of the speed bumps (Templeton et al.; 2001). During severe rains, material gathered under the rubber mats caused additional lifting and curling of the edges (Templeton and Rees, 2001). Portland, on the other hand, has built a number of temporary speed humps, with no reported issues (City of Portland, 2001).

Certain variables must be examined before a decision on the optimum material for permanent speed bumps can be made (Quora, 2016):

1. Material used for the existing road must be considered as this affect the aesthetic and bonding properties of the bumps.
2. Cost of the material: concrete is more expensive than asphalt, but has a longer life (durable) and can handle truck loading than asphalt.
3. Noise level: asphalt in general is quieter than concrete. Asphalt are constructed in such a way that they offer a smooth surface that does not have crack that might
4. Climate condition needed for installation: concrete can be place almost any time of the year. Asphalt can only be placed in warm weather as the oil is not even available in the winter.

All speed limiting measures, including speed bumps, should be prominently visible to alert drivers to slow down and avoid vehicle damage or loss of control. This effectively excludes the possibility of the public road authority being held legally liable. Pre-warnings, design speed signs, contrasting materials, and protecting bollards are commonly used in most countries' speed bump installations.



fig. 2.1. Typical W8-1 Bump warning sign (FHWA, 1998)

2.11 Classification of speed bumps

The following are the geometries of road bumps that are categorized according to their shapes (Oke, S.A. et al., 2007): (i) Conical form; (ii) Hollow rectangular; (iii) Heaped rectangular; (iv) Combination of Conical and Heaped Rectangular; (v) Combination of Conical and Hollow Rectangular; and (vi) Combination of Hollow and Heaped Rectangular.

2.12 Generalized standards and guidelines

The following are general standards and guidelines that apply to all speed bump applications according to LATM (2008).

I. Grade

On street sections with a gradient of equal to or less than 5%, speed bumps may be added. Installation of speed bumps on street sections with a gradient of more than 5% must be based on an engineering review to ensure that the installation does not pose an unnecessary danger to traffic safety. On streets with a slope of more than 8%, speed bumps are not permitted.

II. Curvature proximity

An engineering review should be undertaken prior to the construction of speed bumps along horizontal roadway curvature to ensure that the speed bump installation, in conjunction with the design speed of curves, will allow for safe vehicle passing. According to the MUTCD, speed bump warning signs should be situated in such a way that approaching motorists can see them clearly.

III. Street condition

Prior to any proposed bump construction, the maintenance bureau should inspect all streets. The maintenance bureau will assess if the current conditions are sufficient to handle the impact loads induced by the bumps, as well as whether any pavement maintenance is required. If it is decided that improvements or maintenance are required, this work should be undertaken prior to the construction of bumps.

IV. Curbs

On streets without a curb, speed bumps may be erected. However, precautions such as the placement of road side delineators may be required to avoid tense situations near bumps in locations lacking curbs.

V. Driveways

To avoid potential car collisions, speed bumps should be built as far away from driveways as feasible, and no specific parking removal is necessary on or near speed bumps.

VI. Diversion potential

Adjacent roadways that the engineer has identified as having the potential to be impacted by vehicle diversion from the speed bumped street should be monitored.

VII. Bus stations

Speed bumps should be avoided where possible in street sections where transit vehicles must transition from the travel lane to the curb stop. Speed bumps should be placed in such a way that transit vehicles can transverse them perpendicularly to the road, if at all practicable.

VIII. Travel lane

According to the rules, speed bumps must not be erected on streets with more than one travel lane. Speed bumps are not permitted in designated left or right turn lanes. When considering speed bumps on routes with continuous left turn lanes, extra caution is advised. Speed bumps must be built throughout the entire width of the street surface in all situations.

2.13 Factors that affect the installation of speed bumps

According to Austroads (2004), some important variables to consider while installing road bumps include the following.

I. Altitudes

This is the absolute height of a location, usually measured from sea level. As latitude increases, temperature gets lower. Webster and Layfield (2002) investigated in his study

that surveys of altitude show that many bumps appear to be super road bumps or raised table.

II Location

Only 30mph (Hass-klau et al., 1992) and 50km/h (TAC, 2000) streets should have road bumps installed. "The applicability in terms of peak hourly volume for all three types is up to a maximum of 600 motor vehicles" (Hass-klau et al., 2001).

III Gradient

When placing speed bumps, the gradient of the road is also a crucial issue to consider. The type of speed bump to install on the road is determined by the grade. For example, 75mm/100mm high bumps have been built on roads functioning as bus routes with gradients ranging from 5 to 10% without causing any issues (TAC, 2000).

VI. Grounding

The sort of speed bump to be erected on the street is also determined by the vehicle's ground clearance. Sports cars can have unladen ground clearances as low as 100mm, which drops to about 30mm when fully laden, and studies have shown that longitudinal straddling can occur when the vehicle's wheel base is longer than the bump. To reduce the risk of grounding, road bumps should be no more than 75mm in height (DOT, 2005).

2.14. Warrants for the Installation of speed bumps

The construction of road undulations on public streets will not be considered until the City Engineer determines that all of the following conditions are met for the whole

proposed street section (City of Bakersfield, 1997):

1. The daily average traffic volume must be greater than 500 but less than 2500 vehicles.
2. The street shall have a posted speed limit of 25 mph or be unposted with a prima facie limit of 25 mph.
3. More than two-thirds (66.7%) of the surveyed motorists must exceed the posted or prima facie speed limit or the 85th percentile must exceed the posted or prima facie speed limit by 10 mph.
4. The street shall not be over 44 feet wide.
5. The street shall have no more than 2 through traffic lanes. The curb adjacent to the road undulation locations must be of the raised six or eight inch standard barrier curb type and not roll-over curb.
6. The street shall have good vertical sight distance, pavement surface quality horizontal sight distance, drainage and street lighting. It must be free of unusual features which might affect the operation of road undulations.
7. The street shall be residential or local street meeting the following definitions as stated in the California Vehicle Code: "A residential street is defined as a road having 13 or more buildings on one side of the road or 16 or more buildings on both sides of the road, within a distance of 1/4 mile. Buildings must be located within 75 feet of the roadway curb face and they must face and access the street. The street must be at least 300 feet in length and not exceed a total of one mile.

8. To avoid approach speeds of greater than 40 mph, the location of the first proposed road undulation shall be such that the approach speed in advance of the first undulation can be effectively controlled via a physical design feature such as a curve or controlled intersection.
9. Installation of a road undulation will not be permitted where substantial diversion of traffic to other local street will occur as determined by the City Engineer.
10. Road Undulations shall not be considered for streets that serve as bus routes or are commonly used by emergency vehicles as an access corridor.
11. Road Undulations shall not be installed on a street where they would cause an aggregate 30 seconds delay in Fire Department response time or if they cause the response to exceed 6 minutes.
12. Street Lighting must exist on the street blocks where undulations are proposed to be installed.

2.15. Placement of undulations

Road undulations should be placed according to the following guidelines (City of Bakersfield, 1997):

1. Undulations should be placed from 200 to 300 feet away from intersections, stop signs or sharp curves so that drivers are unlikely to approach them at high speed.

This ensures that sufficient driver reaction time is provided.
2. Undulations should be spaced from 200 to 400 feet apart.

3. Undulations should not be placed on streets with grades greater than 10% or in a location that is not clearly visible for at least 200 feet.

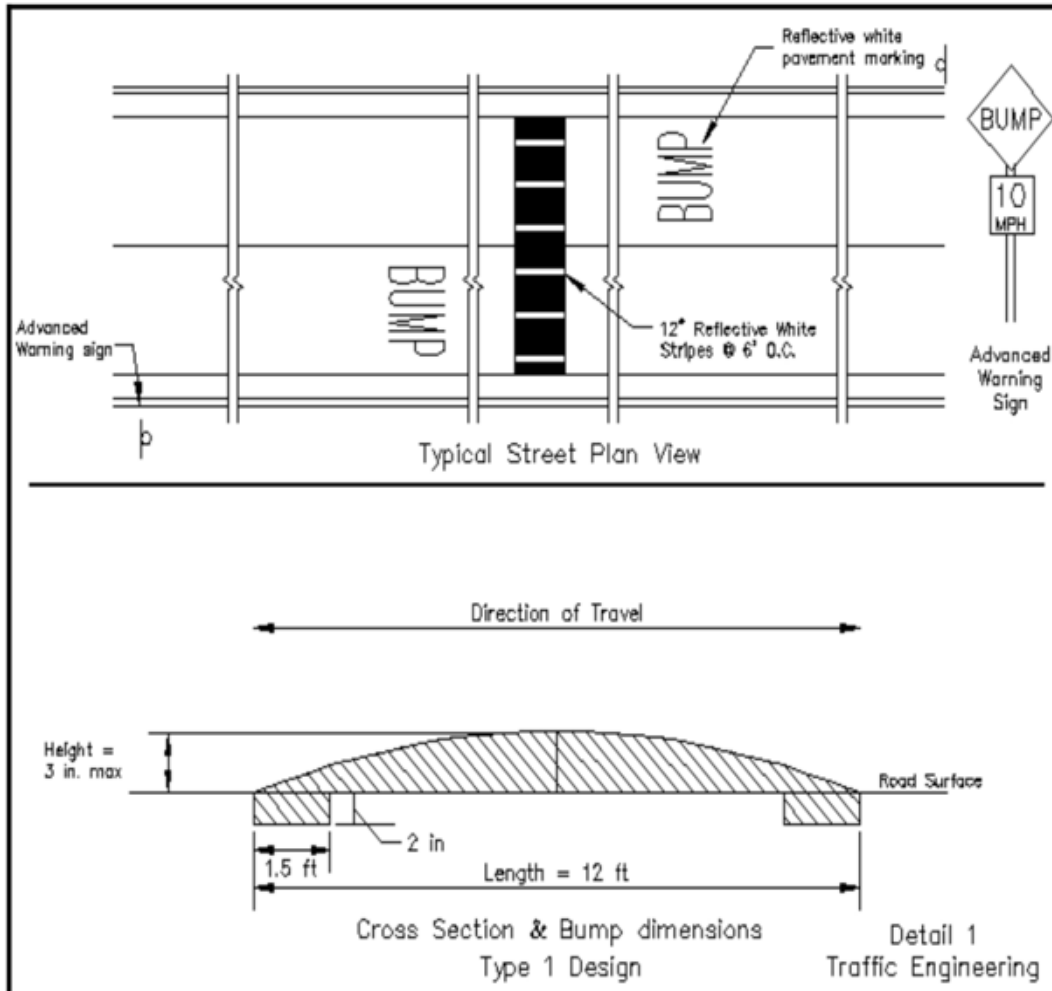


fig. 2.2: A typical detail layout of a speed bump (source: policy of the city of Bakersfield)

2.16. Review of related studies

The speed bump had already been the subject of several studies. Some reports have previously criticized its usage, while others have praised it and encouraged the use of other measures. The following are some of the highlights of this report:

2.16.1. Review of related study done in Nigeria

Bukar (2011) filed a complaint in Eket, Akwa Ibom, Nigeria, regarding the unauthorized building of speed bumps without regard for specifications. People clog public roads for selfish reasons, he noticed, and he believes that a level of supervision and regulation is required. He said that the Local Government Authority has the authority to determine where speed bumps are required, and that he will then approach the commission for specifications to safeguard the safety of people and cars. He emphasized that residents who want to build bumps should seek consent from the Local Government Authority. Bukar concluded that rather than erecting bumps, the effective use of road signs with speed limit to guide motorists would help in tackling the problem of fatal accidents on highways.

In an observation study of road safety around selected primary schools in Ibadan municipality, Oyo State, Southwestern Nigeria carried out by the institute of child health, College of Medicine, University of Ibadan, conclusion was made that features such as road bumps, zebra crossings, and road signs required to ensure road safety around schools are basic and relatively inexpensive to construct and maintain especially when compared to the costs of road traffic injuries to pupils and nation large. In the view of the study findings, urgent action needs to be taken by the local government authorities to ensure that basic road safety features are put in place and maintained around schools in the municipality to ensure safety of pupils on their way to or from school.

Chukwugozi (2014) conducted a case study to investigate the acceptability of speed

bump installation among Ondo State road users. He chose the freeways Akure-Ado, Akure-Owo, and Ikare-Owo. One hundred questionnaires were randomly selected and distributed. Findings revealed that bumps installation have negative impact on road users and passengers such as wear and tear of mechanical system of vehicles, frequent puncture of tyres, increase in time spend in getting to destination, stress on body with pains etc. therefore many people complained about the installation.

In the article "Too many speed bumps in Ondo," Dada (2014) explained the people's viewpoint. Though most people agree that bumps reduce speed and road accidents, he claims that the concept has been exaggerated to the point where it has become a pain in the flesh for motorists and passengers. Many of them claimed that bumps inflict more harm than good, while others wished for them since they slow things down. Finally, the author believes that the government should devise a better method of preventing roadway accidents than bump installation.

According to Adebayo (2014), five significant factors were identified as primary causes of accidents in 2013. Bad roads, automobile congestion, a lack of pedestrian walkways, zebra crossings, and pedestrian bridges are among them. Installing a well-designed speed breaker on congested highways ensures that drivers slow down. Other variables that contribute to reduce accidents include having a valid driver's license, wearing a seat belt, reporting accidents to the Federal Road Safety Corps (FRSC) rather than the police, and improving traffic regulations.

2.16.2. Review of related study done in other countries

Chadda and Cross (1985) conducted a survey to analyze the opinions of traffic

specialists on the effectiveness and safety of speed road bumps. Some traffic specialists supported the usage of speed bumps in this survey. There are, however, some others who oppose the use of these devices on public right-of-way because of safety and liability problem. According to the majority of research conducted over the last two decades, speed bumps as a traffic calming strategy have little effectiveness in reducing traffic speeds. Humps or cushions, which are flatter and more effective than speed bumps, are recommended by the scientists as appropriate equipment.

Pau (2002) discusses the findings of his investigation, which focused on an Italian case study. When approaching speed bumps, cars and two-wheel vehicles often try to avoid the vibration and undulation impact that occurs when passing over these speed control devices, according to this study. This may lead to incorrect driver behavior, such as performing manoeuvres or abruptly reducing speed, which may be the cause of some accidents.

Shao (2007) investigated the relationship between the dimensions of speed bumps and the force applied to road surface and inside the vehicles using a simulation method. Finally, it was concluded that when installing speed bumps on highways, some improvements should be done on its width and vertical height in order to reduce its negative effects on vehicles and pavements.

According to the International Organization of Scientific Research (IOSR), the subject of why speed breakers (road bumps) are used instead of rough or flat roads emerges. According to the IOSR Journal, if a car or any other heavy vehicle traveling at 100 mph

on the road passes over this roller installed at road level, the roller will accelerate to approximately 90 mph (due to losses). If a bicycle traveling at 20 mph passes a roller traveling at 90 mph, a collision will occur due to the speed disparity. This is the main reason for using this concept of speed bumps on roads (IOSR, 2015)

Fishman (2001) established the notion of traffic calming, which is used to improve pedestrian, bike, and neighborhood conditions on a route. To lower traffic volume or speed, traffic calming techniques alter the appearance or geometry of a route. Drivers seek different routes as a result of the strategy, which is self-enforcing. Other ways to encourage cars to slow down on local roads include generating a sense of shared space between the vehicle and the residents.

Beckman and Kuch (2000) investigated how the consequences of speed-related road bumps change. (1) Could bump be a speed-limiting factor? (2) Could a bump create a quick and catastrophic loss of down force and adhesion in an aerodynamic car? The researchers looked at how bump violence changed with speed to answer these questions.

In a study by the Las Vegas Neighborhood community in 2003, a traffic management policy on speed bumps was discussed. The aim was to successfully manage the minimization of non-essential vehicular traffic on residential streets and ensure that vehicles use the street at an appropriate rate of speed. The documentation discussed administrative procedure, minimum criteria placement of speed hump monitoring and evaluation, as well as liability concerns.

Smith and Giese (1997) investigated the effects of high traffic levels on residential

neighborhood quality of life. Speed bumps are intended for two-lane or less residential roads with a posted speed restriction of 30 mph or less and an 85th percentile speed of 31-34 mph. After installation, roads with traffic volumes of 600-5000 cars per day are ideal candidates for speed bumps.

The impact of temporary speed bumps and speed tables on vehicle speeds, vehicle speed profiles, and traffic volumes along local and/or for collector roadways in the United States was studied by Hallmark and Smith (2002). After that, data on traffic volume and resident opinion was collected and analyzed. In general, the devices were shown to be effective with the temporary speed table performing as well or better than the speed hump. Both the speed bump and speed table were effective in reducing mean speeds at the device and immediately downstream, while speeds immediately upstream and farther downstream were less likely to be affected. In the immediate vicinity of the speed bump and speed table, the number of cars violating the speed limit was also reduced. However, a review of the obtained volume data revealed no evidence of traffic decline. The findings of the residents polled in this study were similar to those of other jurisdictions. Overall more respondents were supportive of the use of the temporary speed bump/table than opposed. However, the responses from the resident survey related to the preference of temporary device were not conclusive. The temporary speed bump and temporary speed table used in the study were easily installed and removed with little damage to the existing pavement. These temporary devices may also be ideal for jurisdictions that have concerns of snow removal or those that experience unwanted traffic characteristics during certain time of a year only (e.g. recreational areas).

CHAPTER THREE

METHODOLOGY

3.1. Study area

The study focused on a section of the Warri-Sapele road in Warri-South Local Government Area of Delta state. Geographically, the study area is located between latitude $5^{\circ}32'39.2280''$ North of the equator and between $5^{\circ}45'36.9684''$ East of the Greenwich Meridian. Warri-South Local Government Area has a population of 311,970 at the 2006 census. Trading and transportation is the main stay of the economy of the people and this can easily be ascertained by the abundance of road side shops, street hawking and volume of commercial vehicles. The route assessed is a major route which connects the Warri main market, Warri central hospital, Warri township stadium, churches and numerous public and private schools. Fig. 3.1 shows the satellite imagery of the study area.

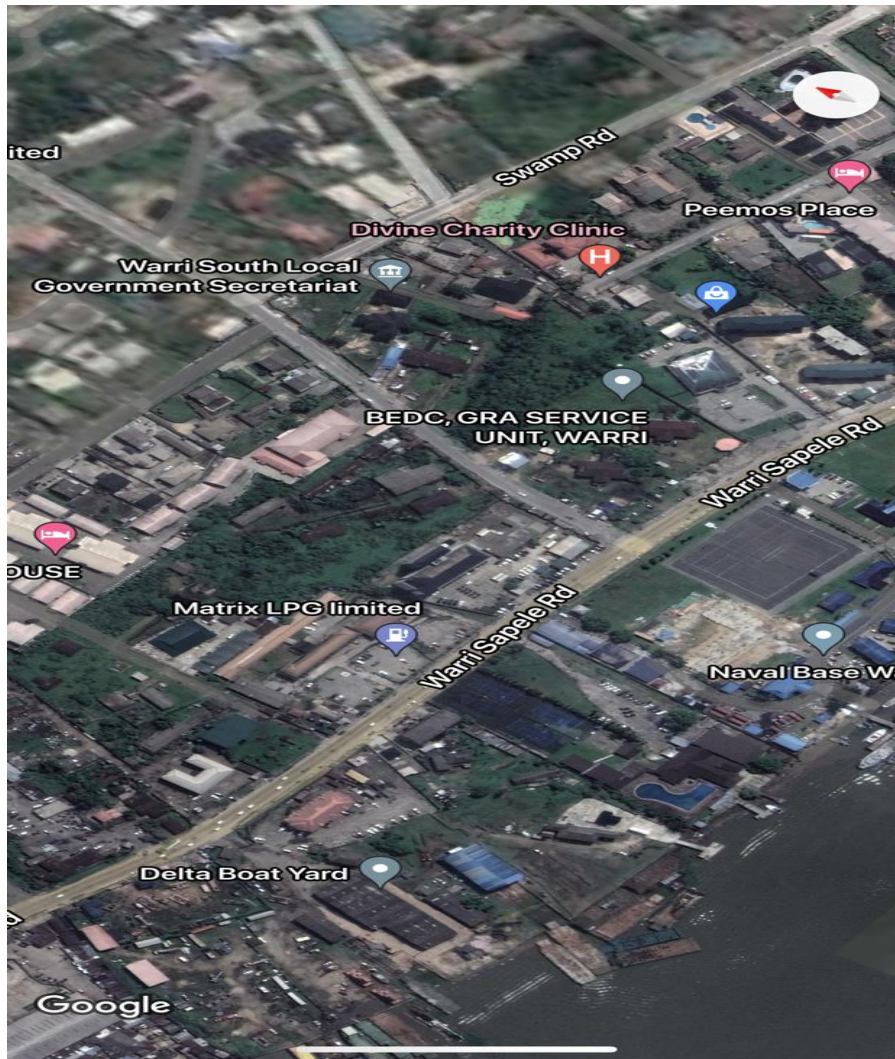


Fig.3.1 Satellite imagery of the study area

3.2 Mixed approach for evaluation of speed bump

The mixed approach strategy was used in this study to evaluate speed bumps effectively.

This method, also known as multi-methodology, entails the use of more than one method to carry out a study finding or investigation, which could include a combination of qualitative and quantitative data or both.

Needless to say, the problem at hand benefits from the advantages of mixed approach.

Hence, the approach is worthy of being adopted for this study. Because the research is grounded on qualitative data gathered through measurement of height, width, spacing

and length were examined with quantitative statistical data from speed bump policies such as Jefferson county speed bump policy, Everett fire department policy on speed bumps, Bakersfield speed bump policy and Local Area Traffic Management, LATM (2008) standard. Table 3.1 shows the various speed bump standards used for the study.

Standard	Height (m)	Width (m)	Spacing (m)	Distance from intersections (m)	Intended speed limit (km/hr)
LATM	0.03-0.10	0.6-1.0	-	-	-
Everett Fire Department	0.076-0.100	-	121.9-213.3	-	-
Jefferson County	-	0.3-1.0	91.4-182.8	<152.4	48.3
Bakersfield speed bump policy	0.076	-	60.9-121.9	60.9-91.4	40.2
Range (Standard Used)	0.03 - 0.1	0.3-0.1	60 - 210	60 -150	50

Table 3.1 Speed bump standards used for the study

3.3. Data collection techniques

The required data were gathered from primary and secondary sources. Thus, the primary sources of data were collected through the following instruments:

- I. Observations
- II. Measurement using steel tape
- III. Questionnaires.

The secondary sources of data were collected using speed bump policies and standards available under the transportation and engineering division of Jefferson county and The

Fire Marshal's Office of Everett fire department, both located in the United States of America.

3.3.1 Observations

Personal and visual observation of the operation on the use of the speed bumps in the selected areas was carried out. This was done so as to check the kind of activities going on in the these areas, the congestion of the area under study, the type of road bump used, materials used for the construction of such road bumps and the ease in which vehicle transit the road bump.

3.3.2 Measurement using steel tape

Measurement of the length, height, width, and the spacing between one bump to another in the study area were carried out using geometrical instruments including steel tape. The width of the bumps was taken as the width of the road section. The height of the bumps were measured in a vertical direction from the road surface to the vertex of the bump. The length of the bumps were measured in a horizontal direction from one point of zero height of the bumps to the other point of zero height on the bumps other side. The spacing between the bumps were measured in-in of two respective bumps.

3.3.3. Questionnaire

The drivers and other road users in the selected rout were given opportunity to express their take on the effect of the bumps on the road. The questionnaires were designed to collect information on effects of bumps on roadways and vehicles in Delta State with reference to the study area. Also, the questionnaire covered reasons for construction of the bumps and activities that occur in that area. Others are the effectiveness, relevance and adequacy of the speed bumps in the study area.

The questionnaires were distributed and retrieved on spot. The primary data was also complemented by observation and interview.

3.4. Speed bumps modeling

Although speed bumps are efficient at reducing vehicle speeds, their use is occasionally contentious because they can increase traffic noise and, if traveled at too high a speed, can damage automobiles. Poorly built speed bumps that are too tall or have too acute an angle can be distracting for drivers, and cars with limited ground clearance may find it difficult to navigate, even at low speed.

Speed bump modeling involves a copy of an object geometry or configuration, especially one made on a smaller scale than the original. According to Advances in Mechanical Engineering, this will be based on two basic inputs; the length of the bump (L) and the height of the bump (H).

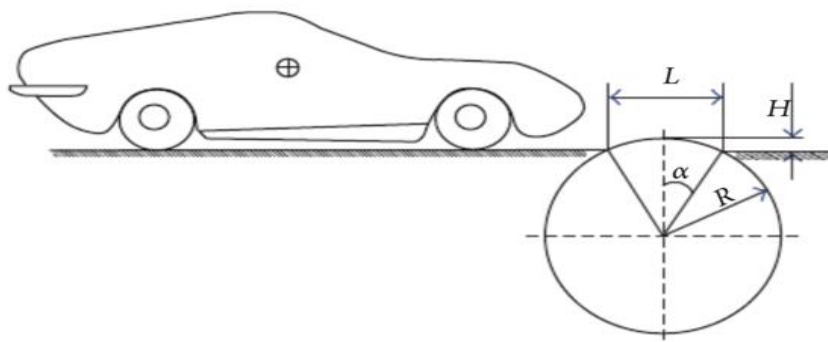


Fig.3.2 Bump Modeling (source: Advances in Mechanical Engineering)

Attending to bump regulations the bump must be part of a circle. On one hand;

$$R \cdot \sin a = L/2 \Rightarrow R = L/(2 \cdot \sin a) \quad (3.1)$$

On the other hand,

$$H = R - R \cdot \cos a \Rightarrow R = H / (1 - \cos a) \quad (3.2)$$

Equalling both equations,

$$H / (1 - \cos a) = L / (2 \cdot \sin a) \Rightarrow H \cdot \sin a / (1 - \cos a) = L / 2 \quad (3.3)$$

Substituting the sin a,

$$(H \cdot \sqrt{1 - \cos^2 a}) / (1 - \cos a) = L / 2 \quad (3.4)$$

Operating,

$$H \cdot \sqrt{1 - \cos^2 a} = L / 2 - L / 2 (\cos a) \quad (3.5)$$

Operating and reorganizing terms,

$$(L^2 / 4 + H^2) \cdot \cos^2 a - (L^2 / 2) \cos a + (L^2 / 4 - H^2) = 0 \quad (3.6)$$

Finally, making the following change of variable $x = \cos a$ we have

$$(L^2 / 4 + H^2) x^2 - (L^2 / 2) x + (L^2 / 4 - H^2) = 0 \quad (3.7)$$

For a given height (H) and length (L) of the bump, angle a used to define the bump geometry is obtained by solving

$$(L^2 / 4 + H^2) \cdot x^2 - (L^2 / 2) x + (L^2 / 4 - H^2) = 0 \quad (3.8)$$

Where $x = \cos a$

Once angle a is found, the radius of the bump circle is calculated either in terms of the bump length (L)

$$R = (L/2 \cdot \sin a) \tag{3.9}$$

Or in terms of the height of the bump (H)

$$R = H / (1 \cos a). \tag{3.10}$$

Yielding the same result

However, in order to completely define the bump geometry the exact horizontal and vertical coordinates of a discrete set of points of the bump are needed. Given that the bump has a symmetric geometry with respect to its central axis, the left side of the bump has been discretized as follows (depicted in Fig.3.3).

The aim of this discretization is to find pair values of time (t) and vertical displacement (y) for each of the points, when

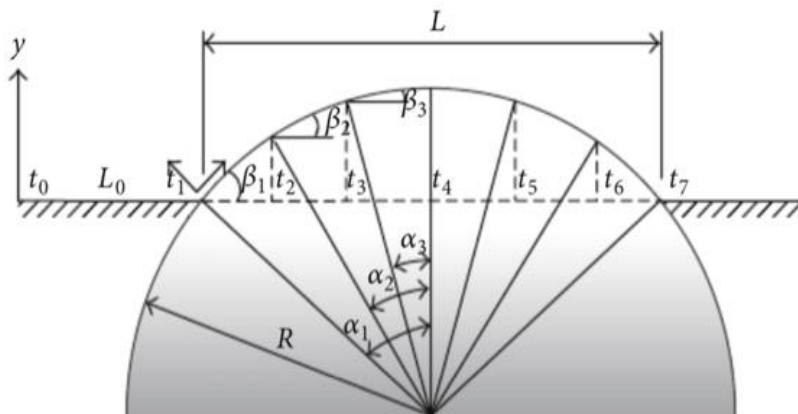


Fig. 3.8: Discretization of the speed bump (source: Advances in Mechanical Engineering)

$$t_0 = 0, \quad t_1 = L_0/V$$

$$t_2 = (t_1 + (R \sin a_1 - R \sin a_2))$$

$$x (\cos (\arctan ((R \cos a_2 - R \cos a_1) / (R \sin a_1 - R \sin a_2))))^{-1} \cdot (1/V)$$

$$t_3 = (t_2 + (R \sin a_2 - R \sin a_3))$$

$$x (\cos (\arctan ((R \cos a_3 - R \cos a_2) / (R \sin a_2 - R \sin a_3))))^{-1} \cdot (1/V)$$

$$t_4 = t_3 + [(R \sin a_3) / \cos (\arctan ((R \cos a_3 - R \cos a_2) / (R \sin a_2 - R \sin a_3)))] \cdot (1/V)$$

$$t_5 = t_4 + (t_4 - t_3), t_6 = t_5 + (t_3 - t_2),$$

$$t_7 = t_6 + (t_2 - t_1). \tag{3.11}$$

And the vertical coordinate is obtained as

$$y_0 = 0, y_1 = 0,$$

$$y_2 = R \cdot \cos a_2 - R \cdot \cos a_1,$$

$$y_3 = R \cdot \cos a_3 - R \cdot \cos a_1,$$

$$y_4 = H, y_5 = y_3, y_6 = y_2,$$

$$y_7 = 0, y_8 = 0. \tag{3.12}$$

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Results

Data on the geometric characteristics, spacing, materials utilized, and existing circumstances of speed bumps, as well as information on the effects of bumps on the environment, vehicles, and the study area, came from research conducted in the study area. Relevant information on the reasons for the installation of speed bumps in selected regions, activities that occur in these areas, efficacy, relevance, and suitability of the speed bumps in the study area was also obtained through the use of the questionnaire.

4.1.1. Results of the parameters of the road bumps.

Results obtained from the measurement of the height, length and width of speed bumps, physical observation of the material used and the existing ground conditions of the bumps in the study are presented in Tables 4.1-4.2.

Table 4.1: Parameters of Speed Bumps Obtained at Warri-Sapele Road

Bump s	Height from the pavement (m)	Width (m)	Length of speed bump (m)	Width of road (m)	Standard	
					H (m)	W (m)
1	0.151	0.46	7.2	7.2	0.03 - 0.10	0.3 - 1.0
2	0.149	0.44	7.2	7.2	0.03 - 0.10	0.3 - 1.0
3	0.145	0.44	7.2	7.2	0.03 - 0.10	0.3 - 1.0
4	0.150	0.46	7.2	7.2	0.03 - 0.10	0.3 - 1.0
5	0.146	0.43	7.2	7.2	0.03 -	0.3 - 1.0

					0.10	
6	0.139	0.40	7.2	7.2	0.03 - 0.10	0.3 - 1.0
7	0.142	0.42	7.2	7.2	0.03 - 0.10	0.3 - 1.0
8	0.140	0.40	7.2	7.2	0.03 - 0.10	0.3 - 1.0

4.1.2. Materials used and existing conditions

Table 4.2: Materials Used and Conditions of Speed bumps along Warri-Sapele

Road

Bumps	Materials used	Existing Condition
1	Asphalt	Good
2	Asphalt	Good
3	Asphalt	Good
4	Asphalt	Good
5	Asphalt	Good
6	Concrete	Good
7	Concrete	Good
8	Concrete	Good

4.1.3. Spacing of the road bumps

Data acquired from the measurement of the distance between two consecutive speed bumps are shown in table below.

Table 4.3 Spacing of the road bumps at Warri-Sapele Road

Bumps	Spacing (m)	Standard
1 - 2	62	60 - 210
2 - 3	60	60 - 210
3 - 4	64	60 - 210
4 - 5	59	60 - 210
5 - 6	61	60 - 210
6 - 7	78	60 - 210
7 - 8	39	60 - 210

4.1.4. Results obtained from questionnaires

Table 4.4. Question 1. Rate how often you use this route?

	Very High	High	Low	Very Low
TOTAL	29	90	29	2
PERCENTAGE	19.33%	60%	19.33%	1.33%

Table 4.5. Question 2: volume of traffic on this route

	Very High	High	Low	Very Low
TOTAL	45	84	20	1
PERCENTAGE	30%	56%	13.33%	0.67%

Table 4.6. Question 3: Speed rating of vehicles before erection of bumps

	Very High	High	Low	Very Low
TOTAL	84	45	20	1

PERCENTAGE	56%	30%	13%	0.67%
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Table 4.7. Question 4: Speed rating of vehicles after erection of bumps

	Very High	High	Low	Very Low
TOTAL	15	23	97	15
PERCENTAGE	10%	15.33%	64.67%	10%

Table 4.8. Question 5: Confidence in using the road before the erection of bumps

	Very High	High	Low	Very Low
TOTAL	29	90	29	2
PERCENTAGE	19.33%	60%	19.33%	1.33%

Table 4.9. Question 6: Confidence in using the road after the erection of bumps

	Very High	High	Low	Very Low
TOTAL	16	29	80	25
PERCENTAGE	10.67%	19.33%	53.33%	16.67%

Table 4.10 Question 7: Occurrence of accident rating before the erection of bumps

	Very High	High	Low	Very Low
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TOTAL	53	69	26	2
PERCENTAGE	35.33%	46%	17.33%	1.33%

Table 4.11 Question 8: Occurrence of accident rating after the erection of bumps

	Very High	High	Low	Very Low
TOTAL	13	21	96	20
PERCENTAGE	8.67%	14%	64%	13.33%

Table 4.12 Question 9: How would you describe the speed bump in this location to the others you have encountered: better?

	Better	Fair	Too high
TOTAL	9	86	55
PERCENTAGE	6%	57.33%	36.64%

Table 4.13 Question 10: Do vehicles easily navigate over the speed bumps?

	Yes	No	Can't say
TOTAL	61	50	39
PERCENTAGE	40.67%	33.33%	26%

Table 4.14 Question 11: How would you rate the condition of most vehicle passing over the speed bump, are the vehicle?

	Very Good	Good	Fair	Bad
TOTAL	4	81	59	6
PERCENTAGE	2.67%	54%	39.33%	4%

Table 4.15 Question 12: Has speed bump done more harm(damage) than good?

	Yes	No	Can't say
TOTAL	16	123	11
PERCENTAGE	10.67%	82%	7.33

Table 4.16 Question 13: Do you think the speed bumps are necessary for this location?

	Yes	No	Can't say
TOTAL	78	40	31
PERCENTAGE	52%	26.67%	20.67%

Table 4.17 Question 14: Would you have loved or want the speed bump in this location to be removed?

	Yes	No	Can't say
TOTAL	22	121	7
PERCENTAGE	14.67%	80.67%	4.67%

Table 4.18 Question 15: If there are other route to your destination without passing this speed bumps, would you still follow this same route?

	Yes	No	Can't say
TOTAL	52	78	20
PERCENTAGE	34.67%	52%	13.33%

Table 4.19 Question 16: What do you love most about this speed bump?

Comments	Number of response
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Increased safety	78
Reduced speed	43
Increase drivers consciousness	7
No response	22

Table 4.20 Question 17: What do you dislike most about this speed bump?

Comments	Number of response
Damage to vehicles	33
Delay	29
Overcrowding	7
Poor design	32
To many	12
No response	37

4.1.4 A standard speed bump model

A collection of standard policies on speed bumps including LATM, Jefferson speed bump policy, Everett fire department and City of Bakersfield speed bump policies show a Maximum speed bump height of 150mm and spacing interval of 90mm to 180000mm. Standard speed bump widths range from 300mm to 1000mm. A combination of these values is to give a speed bump with a maximum speed limit of 50km/hr as stipulated by the Nigeria Highway Code.

The key variables utilized for this speed bump model are the height, width and spacing or distance between two consecutive bumps.

Plan view and Cross section view of a standard speed bump.

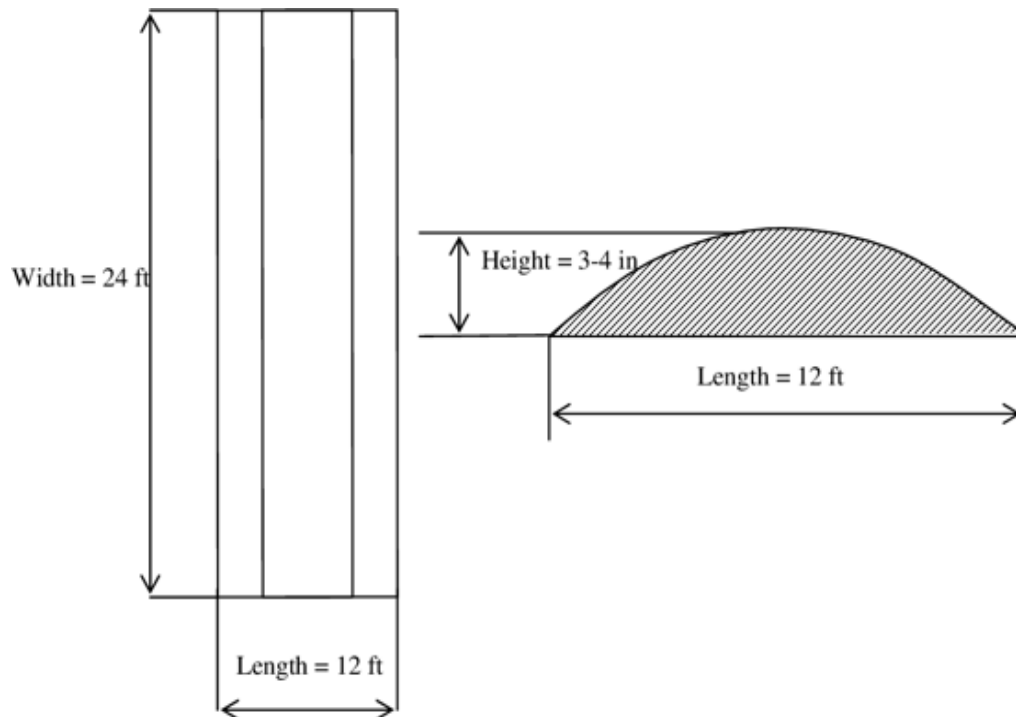


Fig 4.1: Modeled Speed bump for case study area.

Length of speed bump = Road width

Speed bump width = 300mm - 1000mm

Height of speed bump = 30mm - 100mm

4.2. Discussion of results

Table 4.1 - Table 4.2 showed the parameters of road bumps obtained from the study area. It was observed that most of the material used for the speed bump construction were made of asphalt. Only 37.5% of the total number of speed bumps investigated were made of concrete while the remaining 62.5% were made with asphalt. The height

and width of the speed bumps were investigated and was found that all the heights of constructed speed bumps along the Warrii-Sapele road were not within acceptable limits. Also the spacing of the bumps were investigated. However, from Table 4.3, only 25% of the existing speed bumps were of spacing below the standard while 75% of the speed bumps satisfied the spacing standard. All speed bumps along Warri-Sapele road were found to be in good condition.

According to Table 4.10, 35.33% of respondents agreed that the likelihood of an accident in the research region before the construction of bumps on the highway was very high, 46% agreed that it was high, 17.33% agreed that it was low, and 1.33% agreed that it was very low. From Table 4.11, the respondents agreed that the occurrence of accidents after the erection of bumps on the highway of the study area was 64% (low) and 13.33% (very low). Comparing Table 4.10 and Table 4.11, this is an indication that the erection of bumps reduces the number of accidents victims on the route.

Table 4.10, 4.11, 4.12, 4.13, 4.18, 4.19 and 4.20 all showed the effect of speed bumps as indicated by the respondent. From Table 4.15, 82% of the respondent indicated that speed bump had done more good than harm to them. Respondent expressed why they loved the device and also why they hate the device.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Base on the result of this research and according to the report published by the Planning Advisory Service Report Number 456 that traffic calming measures are not appropriate for freeways and expressways because settings associated with traffic calming such as concentrated generators of pedestrian activity, activities along and across the streets, neighborhood streets, sensitive land uses and Transition zones are not present along freeways and expressways, this study appraised the use of speed bumps as a traffic calming device along Ugbowo-Lagos road with the intention of enhancing safety of residents and vulnerable in the vicinities. The use of bumps had been investigated, though the bumps reduced over-speeding but the construction is far from professional initiative and is either illegally motivated by communities or those residing close to highway or at times erected for quenching the state of pandemonium that was arising from the killing of community members along highway by over speeding motorists. Since the residents of these communities insisted not to open the road for almost a day in every case until bumps were erected, the demand became instantaneous and the bumps were indiscriminately erected and had no recourse to specifications (the spacing was in short intervals with variations in the size of their widths and heights of the bumps). Although the speed bumps minimize accidents and injury in the area, yet aggravated accidents may occur particularly if the drivers were not conversant with the road.

A model of a standard speed bump for the selected routes based on ground clearance of vehicles and standard speed bump policies have shown that a speed of below 50km/hr can be achieved through the use of speed bump parameters with heights of 30mm-100mm, widths of 300mm-1000mm and spacing interval of 60m-210m.

5.2 Recommendations.

In order to reduce the consequences of speed bumps on the vehicles and residents in the study area as well as to enhance the position impacts, the following recommendations are suggested

- (i) Before the demand for such a device becomes instantaneous, traffic calming devices should be considered on highways where concentrated generators of pedestrian activity, activities along and across streets, residential streets, sensitive land uses, and Transition zones are present.
- (ii) Existing speed bumps should be inspected in accordance with the manufacturer's specifications. Height, width, and spacing should all be calculated according to the specifications. The number of bumps is reduced when the spacing between them is reduced, but the amount of annoyance is increased.
- (iii) Before the device is permanently placed on the current road, it should be practiced using a rubber substance for temporary testing of the effect and permitting familiarity with the device with pedestrians and drivers.
- (iv) On any road, the design and construction of speed bumps shall be regulated.

and the proper department of government's regulations in order to improve operational efficiency and maybe prevent any illegal deployment of the device.

(v) Where particular traffic calming measures are required, other traffic calming strategies such as the speed hump, speed table, speed cushion, and road shortening should be considered.

(vi) Speed bumps should not be employed to collect fees from drivers.

(vii) The Federal Road Safety Commission's (FRSC) drivers' training manual should be updated on a regular basis, and mandatory periodic seminars for drivers should be held to keep their knowledge up to date.

(viii). Instead of bumps construction in limiting speed and stopping accidents on highway. the effective administration and reinforcement of traffic regulations should be combined with the development of Information Communication Technology (ICT) devices in monitoring and tracking speed limits and other traffic offense. violations.

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APPENDIX

QUESTIONNAIRE

DEPARTMENT OF CIVIL ENGINEERING FACULTY OF ENGINEERING, UNIVERSITY OF BENIN

BENIN CITY

Topic: Evaluation of speed bumps along Warri-Sapele Road, Warri.

Dear sir/madam,

I am an undergraduate student of university of Benin and presently undertaking a research work on the topic above in partial fulfillment for the award of bachelor of engineering in the department of civil engineering, faculty of engineering, university of Benin, Benin City.

The questionnaire below is an instrument for data collection for the purpose of the above stated project and any information provided by you will be treated with utmost confidentiality.

Thanks for your anticipated cooperation.

INSTRUCTION

Please read the following questions below carefully and fill in the blank spaces or tick the appropriate box provided in each question.

1. Rate how often you use this route:

very high[.] high[.]. low[.]. very low[.]

2. Volume of traffic on this route:

very high[.] high[.]. low[.]. very low[.]

3. Speed rating of vehicle before the erection of bumps:

very high[.] high[.]. low[.]. very low[.]

4. Speed rating of vehicle after the erection of bumps:

very high[.] high[.]. low[.]. very low[.]

5. Confidence in using the road before the erection of bumps:

very high[.] high[.]. low[.]. very low[.]

6. Confidence in using the road after the erection of bumps:

very high[.] high[.]. low[.]. very low[.]

7. Occurrence of accident rating before the erection of bumps:

very high[.] high[.]. low[.]. very low[.]

8 Occurrence of accident rating after the erection of bumps:

very high[.] high[.]. low[.]. very low[.]

9. How would you describe the speed bump in this location to the others you have encountered:

better[.] fair [.] too high[.]

10. Do vehicles easily navigate over the speed bumps

Yes [] No []. Can't say [.]

11. How would you rate the condition of most vehicle passing over the speed bump, are the

vehicle: very good [.] good[.]. fair[.]. bad[.]

12. From your own view, has speed bump done more harm(damage) than good:

Yes [] No []. Can't say [.]

13. Do you think the speed bumps are necessary for this location?

Yes [] No []. Can't say [.]

14. Would you have loved or want the speed bump in this location to be remove:

Yes [] No []. Can't say [.]

15. If there are other route to your destination without passing this speed bumps, would you

still follow this same route? Yes[] No []. Can't say [.]

16. What do you love most about this speed bump?.....

17. What do you hate most about this speed bump?.....

Thanks for your time.