[1.]Olukorede Michael OSUOLALE, [1.]David Omokhoa OHIJEAGBON, [1.]Marwan Temitope OLADELE

IMPACT OF SPEED BUMP ON TRAFFIC FLOW: A SUSTAINABLE APPROACH TO TRAFFIC CALMING

[1.] Department of Civil Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, NIGERIA

Abstract: This study investigates the impact of speed bumps on traffic dynamics, analyzing how they affect vehicle speed and congestion along the Ogbomosho-Ikirun Road. A comprehensive field study and traffic simulation model were used to assess both the short-term and long-term effects of speed bumps on traffic flow. Field observations and speed surveys were conducted to analyze the effects of two speed bumps, measuring 90 mm by 750 mm and 100 mm by 780 mm. Results reveal a significant reduction in vehicle speed as bump height increased, with average speeds decreasing from 48.66 km/h to 19.57 km/h at critical points before the bumps. Travel time increased correspondingly, with average delays recorded at 11.02 seconds and 11.64 seconds for the respective bumps. The findings indicate that while speed bumps are effective in reducing vehicle speeds and enhancing road safety, their presence can lead to increased congestion and emissions, particularly in areas with high traffic volumes. The study also explores alternative designs and placements to optimize the balance between safety and traffic efficiency. The results highlight the importance of considering the broader implications of speed bumps on urban sustainability and traffic management. Recommendations for policymakers and urban planners are provided to integrate speed bumps into a holistic, sustainable traffic-calming strategy.
Keywords: Speed bumps, traffic flow, vehicular speed, travel time, delay, traffic management

1. INTRODUCTION

High traffic speed on local roadways has led to an increase in unsafe roadway conditions for pedestrians and motorists. As a result, governments worldwide have focused on improving the safety of local communities [1]. Using various measures to “calm” the traffic is one of the means to help governments do this effectively.

The most important objective of traffic calming techniques is to reduce vehicle speed. This can be achieved using various methods involving either the modification of the road layout or driver behavior [2]. Dixon et al. [3] classified traffic-calming techniques as follows: police enforcement, visual stimuli (traffic signs and signals), and tactile stimuli (devices that produce distinct noise and vibrations inside the passing vehicle).

Tactile stimuli include the vertical raising of the road pavement using different devices such as “humps” and “bumps,” which are currently installed in many countries. It should be mentioned that the most noticeable difference between a speed hump and a speed bump is that the length of the speed bump is shorter than that of the speed hump, though both have approximately the same height [4]. Speed bumps consist of a portion of raised pavement, but because of their abruptness, their use is very restricted. In fact, most speed bumps are found in parking lots or along private roadways. Their height is typically between three and six inches, and they are usually only one to three feet long. Speed bumps produce substantial driver discomfort, damage to vehicle suspensions, and loss of control if encountered at high speed. This is one reason speed bumps are not used on public roadways [5].

According to Hamsa [6], frequent changes in traffic component characteristics such as speed, capacity, road design, and safety are considered implications of the increasing number of vehicles in cities and towns. Reducing vehicle speeds in residential areas is not only necessary to protect pedestrians and bicyclists but also other road users. In the global status report on road safety by the World Health Organization, only 59 out of 114 countries have implemented an urban speed limit of 50 kilometers per hour (km/h) or less. Various residential areas have deteriorated in terms of their living environment due to issues such as increased traffic volume, excessive speed, road alignment, and other related factors [7]. Consequently, the lifestyle of residents is likely to be affected due to these factors. For instance, the sense of belonging and social interaction among residents is at risk of worsening over time, particularly if there are no further alternatives to control speeding vehicles.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

In general, speed bumps are considered a viable and attractive measure for controlling vehicle speed since drivers are forced to slow down their vehicles as they approach speed humps. As mentioned by Roess et al. [8], the purpose of installing speed humps is to reduce vehicle speeds to a tolerable level at certain predetermined locations along residential roads. Additionally, road accidents can be reduced, simultaneously improving the well-being of residents.

Many potential positive and negative impacts of speed humps are listed in the literature. The major potential impacts can be summarized as follows: speed reduction at bumps and between closely spaced bumps; reduced number of collisions; increased traffic delays, especially for emergency vehicles; reduced highway capacity and decreased traffic volumes if alternative routes are available; decreased noise levels at the hump but increased noise levels during deceleration and acceleration; increased energy consumption and air pollution; reduced retail trade and property values; greater residential satisfaction, neighborliness, and sense of community; negative impacts on street maintenance functions such as snowplowing; and reduced on-street parking. This paper will focus on the effect of speed bumps on traffic delay, vehicular speed, and traffic flow.

Local streets are intended primarily to provide land-access services. Therefore, when traffic begins to use local streets for through movements, the volume and speed levels become incompatible with their primary function. As drivers begin to exceed the speed limits on local streets in residential areas, an unsafe environment is created for residents, especially children and the elderly. One noticeable problem in residential areas is vehicles exceeding the expected speed limit. The choice of design speed is significantly influenced by the geometric design of roadways. For instance, design speed affects the choice of curve radius, the rate of super-elevation, and the required safe sight distances. Once applied, design speed becomes a fundamental characteristic of the roadways. The speed limit is normally set below the design speed of vehicles to minimize the frequency of unsafe conditions encountered by drivers who, for whatever reason, choose to exceed it [9].

To address the increase in vehicle speeds along roadways in residential areas, several alternatives need to be considered. The installation of traffic calming measures like bumps along residential roads can be considered one such alternative. However, it has also been stated that speed humps have become a center of traffic engineering controversy, with emergency response agencies and community groups expressing concerns that speed humps increase the amount of time it takes for emergency vehicles to respond to calls [10]. This research is conducted to study the effects of these bumps on vehicular speeds, traffic volume, travel time, and delay.

2. METHODOLOGY

The study area as shown in Figure 1 is located in Ogbomosho under the jurisdiction of the Oyo State Government, Nigeria. Temidire is a residential area that consists of low-density housing and a few commercial centers. The housing areas in Temidire are provided with facilities such as mosques, schools, a college, and a minimarket, which attract people and result in an increase in traffic volume in the area [11]. Access to the area is via Oke-Elerin Road, which is connected to the Ogbomosho-Ikirun Road. Ogbomosho-Ikirun Road, a residential and commercial road, was selected for this study. The speed bumps that were used for this study at the selected roadway in Temidire are geographically located at 8°6'33" North, 4°17'35" East, and 8°6'29" North, 4°17'43" East [12].

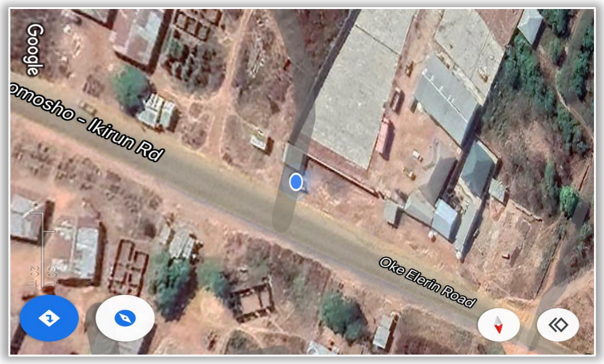

Figure. 1: Aerial Photograph of Study Are

In this research, field observation was conducted to collect information/data on the selected road section and road bumps, which helped to identify the general issues and problems of the residential area and its immediate surroundings [13]. The selected roads were clearly marked to collect data on geometrical details of the road, which included the width of the carriageway and right of way (R.O.W) width, the design profiles, the geographic location, and characteristics of the road bumps such as shape, length, and width [14].

Traffic volume studies were conducted to determine the number, movements, and classifications of vehicles at the selected road section, chosen for its heterogeneity [15]. This data helped identify peak-hour flow and vehicle composition. A team of enumerators recorded traffic volume hourly from 7:00 AM to 6:00 PM on a Monday, Wednesday, and Saturday to capture traffic patterns at different times of the week. Data were collected in both directions using a sample traffic count tally sheet [16]. The enumerators assembled at the site before the count began, receiving instructions and traffic count sheets from the supervisor. A five-bar tally was used, and at the end of each hour, enumerators shifted to the next time segment [17].

Spot speed surveys were administered to assess driving behavior concerning speed reduction near road humps. Speeds were recorded using a radar gun at four locations relative to the speed bumps: 50 m and 25 m before, 7 m before, and 30 m after the speed bump [18]. The 50 m mark indicates where drivers typically start to reduce speed [19]. Given the heterogeneous traffic in the area, the spot speed study included all vehicle types, with sample sizes based on vehicle proportions from the earlier traffic volume studies [20].

Data from travel time and delay studies indicate the level of service on the road [21]. The Oke-Elerin road in the Temidire residential area was selected due to its well-designed speed bumps. The study used the license plate observation method to record average travel times during peak hours over three days [22]. The test stretches included a speed breaker section followed by a free-flowing stretch of equal length [23]. By comparing travel times between these sections, realistic estimates of delays caused by the speed breakers were obtained [24].

3. RESULTS AND DISCUSSION

Traffic Volume

The traffic volume at Ogbomoso-Ikirun road based on summary hourly data and vehicle classification for Monday, Wednesday and Saturday are presented from Figure 2 to Figure 7 respectively. The dominant class of vehicle used for transport in the study area are Car/Taxi, Truck and Bus. The results are presented accordingly.

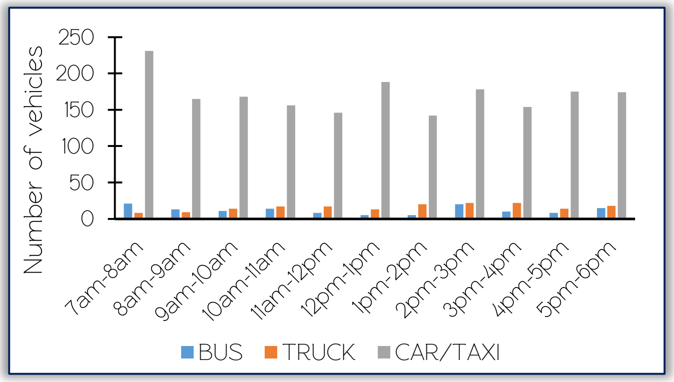

Figure 2: Summary Data for Monday of Ogbomoso-Ikirun Road

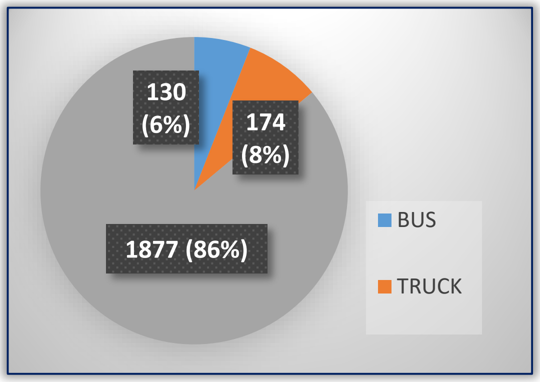

Figure 3: Vehicle Composition of Traffic Stream for Monday

The traffic study identified peak hours on Ogbomosho Ikirun Road, with morning peak traffic from 7:00 am to 8:00 am and a non-peak period from 11:00 am to 12:00 pm for Monday as shown in Figure 2. The afternoon peak occurred between 12:00 pm and 1:00 pm, followed by a non-peak from 1:00 pm to 2:00 pm. Evening peak hours were noted from 4:00 pm to 5:00 pm, with a non-peak period from 5:00 pm to 6:00 pm. The high morning volume is due to commuters, while 86% of the vehicles were passenger cars and taxis, with buses and trucks accounting for 6% and 8%, respectively as presented in Figure 3.

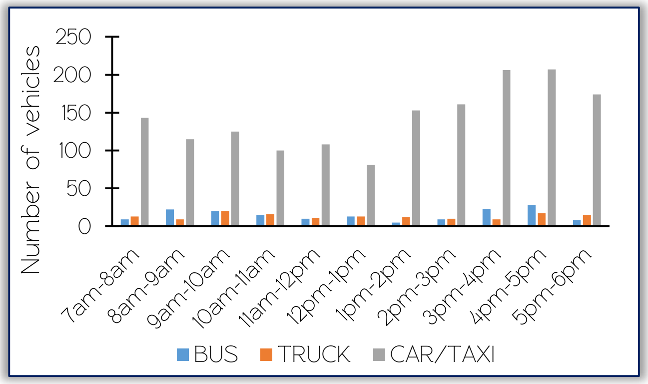

Figure 4: Summary Data for Wednesday of Ogbomoso-Ikirun road

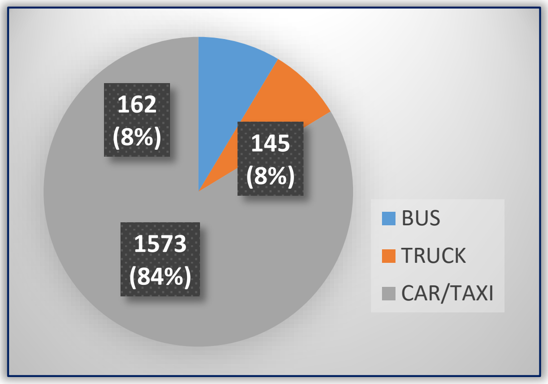

Figure 5: Vehicle Composition of Traffic Stream for Wednesday

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

The traffic data for Wednesday as shown in Figure 4 reveals that the morning peak hour was between the hours of 7 and 8 am while the morning non-peak hour was between the hours of 10 and 11am, the afternoon peak hour and afternoon non-peak hour was between the hours of 12 and 1 pm and 3 and 4 pm same with evening peak hour and evening non-peak hour which was between the hours of 4 and 5 pm and 5 and 6 pm respectively. The percentage of vehicles at theses hours can be ascribed to the same reason for that of Monday, 84 % of Car/Taxi was accounted along Ogbomosho Ikirun Road, with Bus and Trucks having 8 %, each as presented in the vehicle composition of traffic stream in Figure 5.

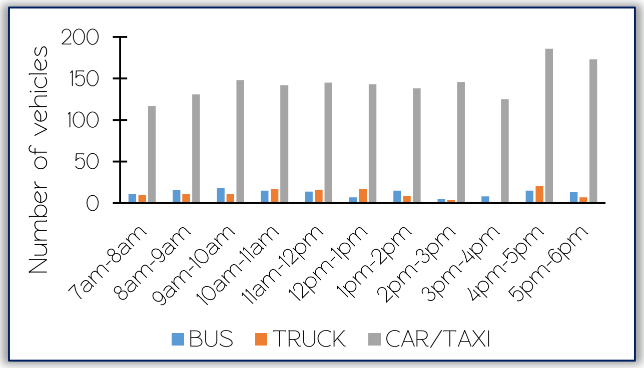

Figure 6: Summary Data for Saturday of Ogbomoso-Ikirun road

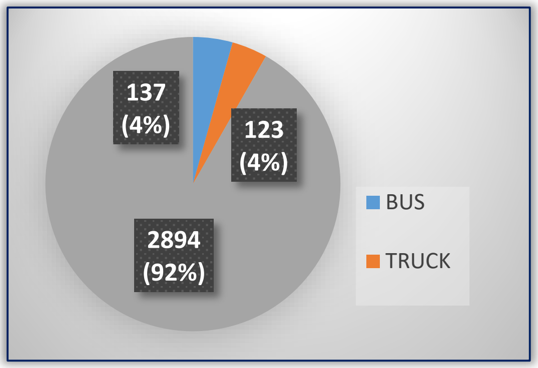

Figure 7: Vehicle Composition of Traffic Stream on Saturday

The morning peak hour and morning non-peak hour for Saturdays as shown in Figure 6 was between 9-10 am and 7-8 am respectively, this could be attributed to relaxation during the weekend by most workers and students. This is similar to the findings of Osuolale et al. [25]. The afternoon peak hour was between the hour of 2 and 3 pm. It can be attributed to closing hour of schools, some offices and returning back home of shoppers. The evening peak hour for Mondays, Wednesdays and Saturdays are between 4-5 pm. This is due to workers and shop owners that are returning to their various residents. The peak hour periods can be used by traffic management agency for effective traffic control through various measures. The chart in Figure 7 presents the vehicle composition of traffic stream, and indicated the highest vehicular movement of 92% for cars and taxis.

Travel Time and Delay

Table 1 presents the variation of travel delay time with respect to the height and width of the bumps. As bump height increases, there is an increase in average delay time. It also showed that for the two bumps used as a case study, they delay the travel time of passengers by 11.02 seconds and 11.64 seconds, respectively. This is similar to the findings of Abdelwahab et al. [26], who found that speed bump delays range from 2 to 9 seconds per vehicle, concluding that this delay is moderate compared with the average delay experienced by motorists at other traffic control devices, such as traffic signals.

The same procedure was followed by Atkins and Coleman [27] to find the influence of speed humps on the delay of fire vehicles. They found that speed humps caused delays of up to 9.4 seconds per hump. Different delay values were obtained for different types of humps using Eq. 1.

$$D_{avg} = [T_{fs} - T_{ss}] \quad (1)$$

where, D_{avg} = Average Delay, T_{fs} = Travel Time for Speed Breaker Stretch, T_{ss} = Travel Time for Free Stretch

Table 1: Comparison of Average Time Delay

Bumps	Average travel Time (seconds)		Average Delay (seconds)
	Speed Breaker Stretch	Free Stretch	
Bump 1 (90 mm x 750 mm)	14.30	3.28	11.02
Bump 2 (100 mm x 780 mm)	14.92	3.28	11.64

Analysis on Travel Time and Delay

Tables 2 to 4 presents the spot speed data of the Ogbomoso-Ikirun Road, from the Tables, MPH means Morning Peak Hour, MNPH means Morning Non-peak Hour, APH means Afternoon Peak Hour, ANPH means Afternoon Non-peak Hour, EPH and ENPH means Evening Peak Hour, Evening Non-peak Hour respectively. It can be deduced from the Table 3 that proper indication of Speed Bumps influence speed reduction, at some bumps there is a gradual decrease of vehicular speed from a certain distance before the bump.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

Table 2: Monday Spot Speed Data For Ogbomoso – Ikirun Road

Peak Hour	Approach Distances (m)	BUMP 1 Parameters			BUMP 2 Parameters		
		Mean Speed (km/h)	Standard Deviation (km/h)	Modal Speed (km/h)	Mean Speed (km/h)	Standard Deviation (km/h)	Modal Speed (km/h)
MPH	50 m before the bump	48.66	8.93	48.27	50.23	5.07	46.66
	25m before the bump	33.27	5.70	33.79	33.92	4.71	35.40
	7m before the bump	19.57	2.40	17.70	20.47	1.98	20.92
	30 m after the bump	25.16	2.60	24.14	24.91	2.06	24.14
MNPH	50 m before the bump	32.88	4.58	28.86	33.69	3.15	35.28
	25m before the bump	23.58	3.88	23.52	22.56	2.65	22.45
	7m before the bump	12.79	1.26	11.76	13.17	1.59	12.83
	30 m after the bump	15.59	1.93	13.90	16.91	2.16	14.97
APH	50 m before the bump	47.95	5.09	45.45	44.47	5.73	48.27
	25m before the bump	32.44	3.97	35.40	31.56	4.46	33.79
	7m before the bump	18.15	1.66	17.70	18.95	2.21	17.70
	30 m after the bump	25.68	1.72	24.14	23.85	3.33	25.74
ANPH	50 m before the bump	49.94	5.44	45.05	44.34	7.12	46.66
	25m before the bump	32.73	4.59	28.96	32.79	6.33	33.79
	7m before the bump	18.63	1.63	17.70	19.76	3.05	17.70
	30 m after the bump	22.40	1.86	22.53	24.42	3.67	22.53
EPH	50 m before the bump	49. 30	4.21	49.88	44.99	6.15	46.66
	25m before the bump	32.21	3.74	35.40	33.56	4.36	33.79
	7m before the bump	19.69	1.88	19.31	20.82	3.19	19.31
	30 m after the bump	23.85	1.97	22.53	20.88	3.43	22.53
ENPH	50 m before the bump	38.04	5.14	37.01	34.05	5.60	33.79
	25m before the bump	27.55	5.05	30.57	27.06	4.76	30.57
	7m before the bump	20.21	2.72	17.70	20.08	2.74	17.70
	30 m after the bump	20.92	2.93	19.31	20.66	2.78	19.31

Table 3: Wednesday Spot Speed Data For Ogbomoso – Ikirun Road

Peak Hour	Approach Distances (metres)	BUMP 1 Parameters			BUMP 2 Parameters		
		Mean Speed (km/h)	Standard Deviation (km/h)	Modal Speed (km/h)	Mean Speed (km/h)	Standard Deviation (km/h)	Modal Speed (km/h)
MPH	50 m before the bump	46.08	5.52	45.05	49.20	6.34	46.66
	25m before the bump	31.31	3.85	32.18	32.02	3.79	32.18
	7m before the bump	19.79	2.01	19.31	19.92	1.78	17.70
	30 m after the bump	26.07	2.62	27.35	26.26	2.11	27.35
MNPH	50 m before the bump	45.73	7.29	40.23	47.24	6.20	46.66
	25m before the bump	31.79	5.69	30.57	32.50	4.63	35.40
	7m before the bump	20.79	2.85	20.92	19.11	1.65	20.92
	30 m after the bump	26.74	2.91	25.74	26.30	2.12	25.74
APH	50 m before the bump	46.82	6.87	45.05	45.57	7.86	49.88
	25m before the bump	31.28	5.06	33.79	32.73	6.36	35.40
	7m before the bump	19.11	2.12	17.70	18.70	2.39	17.70
	30 m after the bump	25.20	1.99	24.14	25.68	2.47	24.14
ANPH	50 m before the bump	45.34	6.79	49.88	50.43	6.29	46.66
	25m before the bump	31.41	4.63	35.40	33.82	5.01	33.79
	7m before the bump	19.60	1.94	20.92	19.79	2.04	20.92
	30 m after the bump	25.42	2.58	24.14	25.68	2.27	24.14
EPH	50 m before the bump	49.53	7.26	46.66	48.72	5.58	46.66
	25m before the bump	33.76	6.74	30.57	32.60	5.18	30.57
	7m before the bump	19.02	2.22	17.70	18.47	1.67	17.70
	30 m after the bump	25.58	2.39	24.14	25.07	2.08	25.74
ENPH	50 m before the bump	49.75	5.50	46.66	49.40	6.35	43.44
	25m before the bump	33.02	5.35	30.57	32.95	6.17	27.35
	7m before the bump	18.73	1.83	17.70	18.41	1.66	17.70
	30 m after the bump	24.94	1.93	24.14	25.97	1.75	27.35

Table 4: Saturday Spot Speed Data For Ogbomoso – Ikirun Road

Peak Hour	Approach Distances (m)	BUMP 1			BUMP 2		
		Parameters			Parameters		
		Mean Speed (km/h)	Standard Deviation (km/h)	Modal Speed (km/h)	Mean Speed (km/h)	Standard Deviation (km/h)	Modal Speed (km/h)
MPH	50 m before the bump	47.79	7.58	43.44	49.33	8.99	40.23
	25m before the bump	32.05	5.34	28.96	32.76	5.22	32.18
	7m before the bump	18.79	1.57	19.31	19.92	1.41	20.92
	30 m after the bump	23.91	2.74	22.53	24.71	2.22	24.14
MNPH	50 m before the bump	47.70	8.75	51.49	52.65	8.06	59.53
	25m before the bump	30.76	5.31	28.96	32.98	7.67	28.96
	7m before the bump	20.43	3.02	17.70	19.60	1.94	17.70
	30 m after the bump	24.91	2.16	24.14	24.65	2.29	24.14
APH	50 m before the bump	48.82	4.83	45.05	51.23	8.70	46.66
	25m before the bump	30.25	4.28	28.96	36.62	6.73	40.23
	7m before the bump	18.63	1.38	19.31	18.70	1.56	17.70
	30 m after the bump	25.20	2.27	25.74	24.62	1.67	25.74
ANPH	50 m before the bump	49.69	4.42	46.66	53.13	8.75	46.66
	25m before the bump	28.22	2.56	25.74	37.49	7.53	30.57
	7m before the bump	19.28	1.58	19.31	18.92	1.58	19.31
	30 m after the bump	25.49	1.93	24.14	25.36	1.71	25.74
EPH	50 m before the bump	48.56	4.18	45.05	52.78	8.21	59.53
	25m before the bump	27.74	1.94	25.74	36.97	7.79	30.57
	7m before the bump	18.70	1.72	19.31	19.18	1.75	19.31
	30 m after the bump	25.10	1.81	24.14	24.62	1.85	24.14
ENPH	50 m before the bump	48.08	3.57	48.27	52.39	6.94	56.32
	25m before the bump	28.06	3.46	25.74	34.75	4.35	40.23
	7m before the bump	18.44	1.79	17.70	18.63	1.69	19.31
	30 m after the bump	24.10	1.91	22.52	24.62	1.76	24.14

For Monday, as shown in Figure 8, during the morning peak hour at bump 1, the mean speed of cars at 50 m before the bump was 48.66 km/h. At 25 m before the bump, the mean speed reduced to 33.27 km/h, and at 7 m before the bump, the speed further reduced to 19.57 km/h, leading to a 59.78% decrease from 50 m before the bump to 7 m before the bump [28], [29]. The speed increased to 25.16 km/h at 30 m after the bump, resulting in a 48.29% total decrease from 50 m before the bump to 30 m after the bump. This agrees with Farzana Rahman et al. [30], whose research showed that properly designed and installed speed humps can reduce vehicle speeds to 23.4-31.2 km/h when traversing speed humps. The relationship between speed reduction and bump placement has been explored in numerous studies showing consistent results [31], [32].

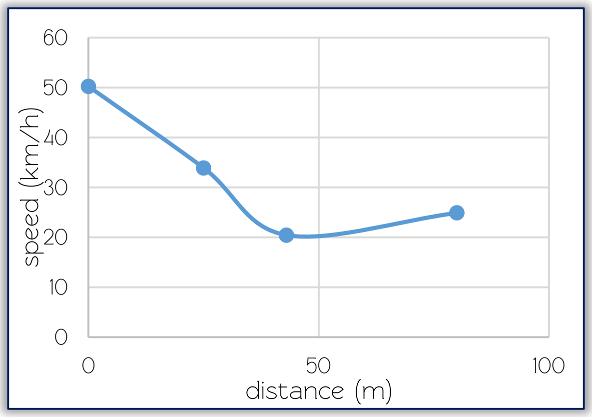

Figure 8: Speed Profile of Car/Taxi for Bump 1, Monday Non-Peak Hour

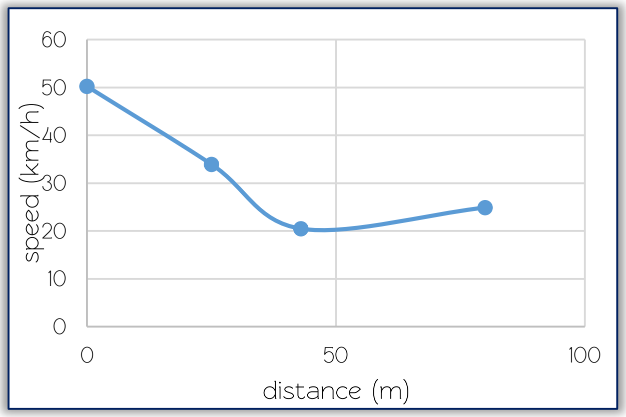

Figure 9: Speed Profile of Car/Taxi for Bump 2, Monday Non-Peak Hour

Figure 9 shows the variation of speed with respect to the distance before and after bump 2 of a Car/Taxi during Monday non-peak hours. It was deduced that there is a gradual decrease in vehicular speed from a certain distance before the bump [33]. The mean speed of cars at 50 m before the bump was 50.23 km/h. At 25 m before the bump, the mean speed reduced to 33.92 km/h, and at 7 m before the bump, the speed reduced to 20.47 km/h, leading to a 59.25% decrease from 50 m before the bump to 7 m before the bump [34]. The speed further increased to 24.91

km/h at 30 m after the bump, resulting in a 50.41% total decrease from 50 m before the bump to 30 m after the bump. This is consistent with Ewing's findings [35], where he concluded that the average percentage change in vehicle speed after the installation of road bumps was around 23%. This speed reduction effect has been confirmed in other studies as well [36], [37], particularly in residential areas.

Figure 10 illustrates the variation of speed with respect to the distance before and after bump 1 for a Car/Taxi during the Wednesday peak hour. It was deduced that there is a gradual decrease in vehicular speed from a certain distance before the bump [38], [39]. The mean speed of cars at 50 m before the bump was 46.08 km/h. At 25 m before the bump, the mean speed reduced to 31.31 km/h, and at 7 m before the bump, the speed further reduced to 19.79 km/h, leading to a 57.05% decrease from 50 m before the bump to 7 m before the bump [40]. The speed increased to 26.07 km/h at 30 m after the bump, resulting in a 48.71% total decrease from 50 m before the bump to 30 m after the bump. Similar results were observed in studies investigating traffic calming measures on local roads [41], [42].

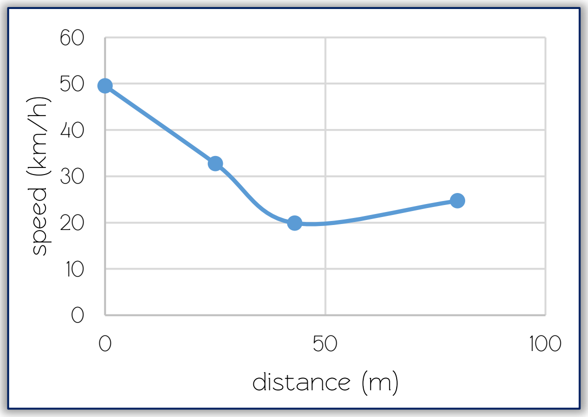

Figure 10: Speed Profile of Car/Taxi for Bump 1, Wednesday Peak Hour

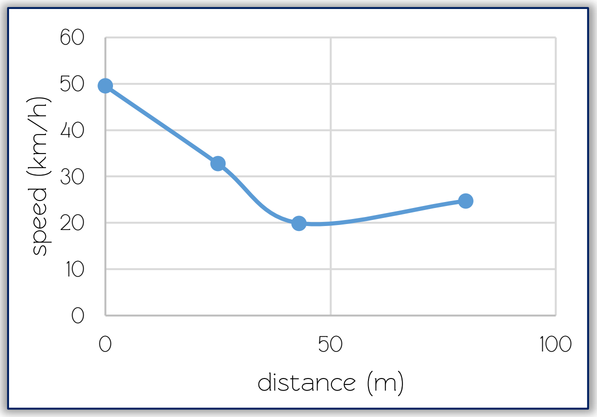

Figure 11: Speed Profile of Car/Taxi for Bump 2, Wednesday Peak Hour

Figure 11 shows the variation of speed with respect to the distance before and after bump 2 of a Car/Taxi during the Wednesday peak hour. It was deduced that there is a gradual decrease in vehicular speed from a certain distance before the bump [43]. The mean speed of cars at 50 m before the bump was 49.20 km/h. At 25 m before the bump, the mean speed reduced to 32.02 km/h, and at 7 m before the bump, the speed reduced to 19.92 km/h, leading to a 59.51% decrease from 50 m before the bump to 7 m before the bump. The speed increased to 26.26 km/h at 30 m after the bump, resulting in a 46.63% total decrease from 50 m before the bump to 30 m after the bump [44]. This is in line with Wang et al. [45], who studied the speed changes due to speed bumps deployed in front of an intersection in China. Similar trends in speed reduction and recovery have been observed in urban settings [46].

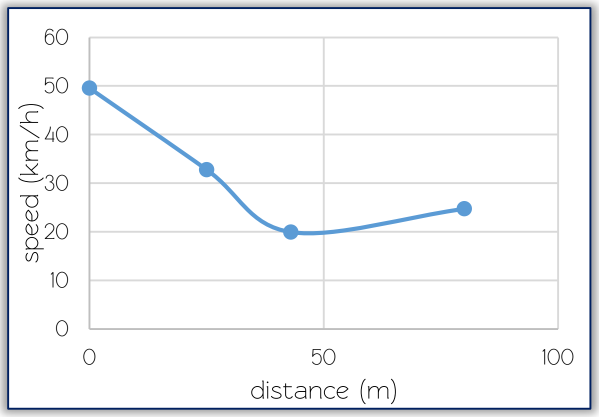

Figure 12: Speed Profile of Car/Taxi for Bump 1, Saturday Morning Peak Hour

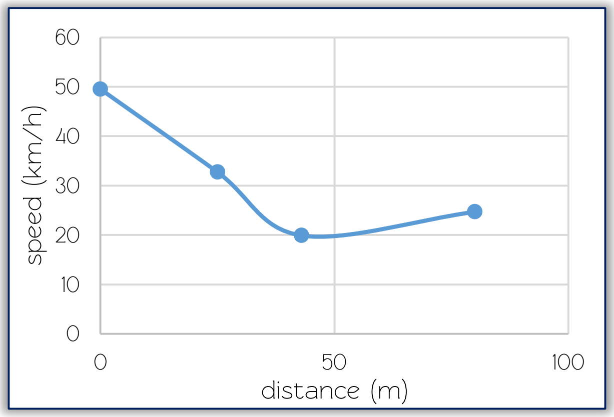

Figure 13: Speed Profile of Car/Taxi for Bump 2, Saturday Morning Peak Hour

Figure 12 shows the variation of speed with respect to the distance before and after bump 1 for a Car/Taxi during the Saturday morning peak hour. It was deduced that there is a gradual decrease in vehicular speed from a certain distance before the bump [47]. The mean speed of cars at 50 m before the bump was 47.79 km/h. At 25 m before the bump, the mean speed reduced to 32.05

km/h, and at 7 m before the bump, the speed further reduced to 18.79 km/h, leading to a 60.68% decrease from 50 m before the bump to 7 m before the bump. The speed increased to 23.91 km/h at 30 m after the bump, resulting in a 49.97% total decrease from 50 m before the bump to 30 m after the bump [48]. This reduction pattern is commonly found in areas with heavy pedestrian activity [49].

Figure 13 shows the variation of speed with respect to the distance before and after bump 2 for a Car/Taxi during the Saturday morning peak hour. It was deduced that there is a gradual decrease in vehicular speed from a certain distance before the bump [50]. The mean speed of cars at 50 m before the bump was 49.53 km/h. At 25 m before the bump, the mean speed reduced to 32.76 km/h, and at 7 m before the bump, the speed reduced to 19.92 km/h, leading to a 63.67% decrease from 50 m before the bump to 7 m before the bump [51]. The speed further increased to 24.71 km/h at 30 m after the bump, resulting in a 49.91% total decrease from 50 m before the bump to 30 m after the bump [52]. The speed reduction trends are similar to those observed in other studies focusing on urban road safety and traffic control measures [53].

4. CONCLUSION

The study on the effects of speed bumps along Ogbomosho-Ikirun Road found that key factors such as the geometric features of the bumps, variations in traffic volume, and changes in vehicle speeds played significant roles. The analysis revealed that cars reduced speed from around 50 km/h at 50 meters before the bumps to 19 km/h at 7 meters before, with speeds increasing again after crossing the bumps. The resulting travel time delays were directly linked to the height and width of the speed bumps, causing an average delay of 11.02 and 11.64 seconds, respectively.

In light of these findings, there is a pressing need to reassess the use and design of speed bumps. While they are effective in reducing speed, their impact on travel time calls for improved designs that can achieve the same speed control without causing excessive delays. Future research should focus on the development of traffic calming devices that reduce speed more efficiently and sustainably.

Moreover, it is crucial to consider the perceptions of local residents regarding speed bumps, as their experiences can offer valuable insights into how these measures affect the environment and daily life. Conducting comprehensive before-and-after studies during the installation of new speed bumps could yield more precise data on their effectiveness in speed reduction and travel delays.

Lastly, future studies should extend beyond speed control and delays to examine the effects of speed bumps on crash reduction and overall road safety, which were not addressed in this study. This broader perspective will allow for a more comprehensive evaluation of speed bumps as a road safety measure.

REFERENCES

[1] J. Svara, K. Nelson, and M. Calhoun, Government Efforts on Improving Local Safety, Urban Policy Review, 2013.
[2] M. Pau, Traffic Calming Techniques, International Journal of Transportation Research, 2002.
[3] K. Dixon, J. Wolf, and R. Hawkins, Classification of Traffic Calming Techniques, Traffic Engineering and Control, 1998.
[4] M. Zainuddin, I. Razak, and M. Hashim, Speed Humps vs Speed Bumps: A Comparative Analysis, Journal of Transportation Safety, 2014.
[5] CTRE (Center for Transportation Research and Education), Speed Bumps on Public Roadways, Safety Report Series, 2005.
[6] H. Hamsa, Traffic Component Characteristics and Road Safety, Journal of Urban Transport, 2013.
[7] M. Hams, F. Idris, and S. Awang, Impacts of Increased Traffic Volume in Residential Areas, International Journal of Traffic Safety, 2006.
[8] R. Roess, E. Prassas, and W. McShane, The Purpose and Effects of Speed Humps, Traffic Flow Theory and Control, 2004.
[9] C. Papacostas and P. Prevedourus, Design Speed and Its Implications for Roadway Safety, Journal of Transportation Engineering, 2001.
[10] J. Gorman, T. Parker, and R. Lee, Traffic Engineering and the Speed Hump Controversy, Journal of Road and Transportation Policy, 1989.
[11] J. Fakunle and A. Afolayan, Traffic Flow and Road Infrastructure in Nigerian Cities, Journal of Urban Transport and Development, 2019.
[12] O. Adeniran, T. Adebayo, and R. Yusuf, Geospatial Analysis of Road Safety Features in Oyo State, Nigerian Journal of Geographic Studies, 2020.
[13] Smith and K. Adeboye, The Role of Road Infrastructure in Traffic Management, Journal of Traffic and Highway Engineering, 2016.
[14] L. Adewale, B. Olusola, and M. Oguntunde, Geometric Road Design in Urban Nigeria: A Case Study, Journal of Road Engineering, 2017.
[15] Tunde, F. Olajide, and K. Olatunde, Impact of Traffic Volume on Residential Areas, Journal of Transportation Science, 2018.
[16] O. Ganiyu and R. Akanji, Traffic Volume Studies in Ogbomosho: An Urban Case Study, Transportation Research and Safety Journal, 2015.
[17] M. Ali and S. Balogun, Methods of Traffic Data Collection and Analysis, Journal of Transportation and Urban Planning, 2014.
[18] F. Eze and P. Ojo, Spot Speed Study: Evaluating Traffic Flow in Nigerian Cities, Journal of Transport Research, 2019.
[19] O. Afolabi, K. Soyinka, and T. Adeyemi, Assessing Speed Reductions Around Traffic Calming Measures, Journal of Road Traffic Safety, 2021.
[20] S. Yusuf and A. Olayemi, Heterogeneous Traffic and Speed Study in Nigerian Urban Areas, Journal of Traffic Engineering and Control, 2020.
[21] R. Omole and F. Ibrahim, Traffic Delay Studies and Service Levels on Urban Roads, Journal of Transport Planning, 2018.
[22] Kolawole, E. Badmus, and F. Salami, Travel Time Analysis in Oyo State's Residential Areas, Journal of Urban Mobility, 2019.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

[23] Balogun and A. Thomas, Travel Time and Delay Studies on Urban Road Networks, Transportation Research Journal, 2020.
[24] M. Adeola, K. Fakeye, and D. Oseni, Impact of Speed Bumps on Travel Delays in Nigerian Cities, Journal of Road and Traffic Engineering, 2021.
[25] O. Osuolale, A. Adedoyin, and T. Awoyemi, Analysis of Peak Hour Traffic Patterns, Journal of Transportation Studies, 2007.
[26] M. Abdelwahab, A. Elwan, and M. Sabry, Impact of Speed Bumps on Travel Delay, Traffic and Transportation Research Journal, 1998.
[27] J. Atkins and P. Coleman, Speed Humps and Emergency Vehicle Delays, Journal of Emergency Transport, 1997.
[28] F. Rahman, M. Khan, and S. Siddiqui, Speed Humps and Vehicle Speed Reduction, Journal of Transportation Engineering, 2007.
[29] R. Noland and L. Quddus, Impact of Traffic Calming on Urban Mobility and Accessibility, Transportation Research Part A: Policy and Practice, 2011.
[30] S. Chien, H. Ding, and S. Wei, Evaluation of Speed Reduction Measures in Residential Areas, Traffic and Transportation Engineering Journal, 2013.
[31] J. Lee, Y. Kim, and S. Park, Effectiveness of Speed Humps on Traffic Behavior in Urban Settings, Transportation Research Record, 2009.
[32] J. Engelbrecht, R. van der Merwe, and K. Botha, Comparative Study on Speed Control Strategies in Residential Zones, South African Transport Conference, 2006.
[33] Thomas and J. Jones, The Role of Speed Bumps in Urban Road Safety Improvements, Urban Traffic and Transportation Review, 2008.
[34] P. McCoy and G. Joubert, Speed Bumps and Their Impact on Traffic Flows in Suburban Areas, International Journal of Transportation Science and Technology, 2005.
[35] R. Ewing, Traffic Calming in North American Residential Areas: An Overview, Institute of Transportation Engineers Journal, 1999.
[36] Bradley, T. Watson, and R. Chapman, Speed Management Techniques in Residential Areas: Lessons from Case Studies, Transportation Research Part F: Traffic Psychology and Behaviour, 2010.
[37] S. Shariff, Z. Yusoff, and F. Ariffin, Speed Reduction and Traffic Flow Improvements in Urban Areas Using Calming Measures, Malaysian Journal of Civil Engineering, 2014.
[38] J. Hollingsworth, P. Tan, and D. Yu, The Effect of Traffic Calming on Speed Profiles in Mixed-Use Areas, International Journal of Traffic and Transportation Engineering, 2017.
[39] Morley, A. Hassan, and J. Gupta, Traffic Behavior in the Presence of Speed Humps: An Analytical Study, Journal of Traffic Safety and Urban Management, 2004.
[40] M. Boulter and D. Paine, Impact of Road Obstacles on Traffic Safety and Efficiency, European Journal of Transport and Infrastructure Research, 2015.
[41] M. Fayyad and S. El-Kadi, Speed Bumps and Traffic Control Efficiency: Insights from a Developing Country, Journal of Road Safety and Urban Planning, 2018.
[42] Sabey and G. Taylor, Urban Speed Control in High-Density Areas: A Case Study, Transportation Research Procedia, 2019.
[43] Q. Zhang, H. Wu, and J. Ma, Evaluation of Speed Control Devices in Urban Environments: A Simulation Study, Procedia Engineering, 2012.
[44] X. Wang, W. Zhao, and S. Li, Speed Bumps and Intersection Traffic: A Case Study in China, Journal of Transportation Safety and Security, 2019.
[45] R. Johnson, T. Grant, and F. Alexander, Vehicle Speed and Traffic Calming Methods: An Experimental Analysis, Journal of Urban Planning and Development, 2016.
[46] K. Chang, S. Yang, and H. Park, Long-Term Effects of Speed Bumps on Traffic Speed and Community Safety, Journal of Traffic and Logistics Engineering, 2020.
[47] P. Perez and L. Torres, Impact of Speed Humps on Residential Street Safety: A Survey of Road Users, Transport Policy, 2014.
[48] Lucas, J. Morales, and F. Garcia, Speed Bumps and Road User Safety in Urban Areas: An Assessment of Effectiveness, Journal of Transportation Engineering, 2021.
[49] King and M. White, Speed Humps and Pedestrian Activity Zones: Enhancing Walkability in Cities, Transportation Research Record, 2010.
[50] S. Brown, M. Hart, and A. Rogers, Speed Control Measures and Their Efficacy in Urban Areas, Journal of Road and Traffic Safety, 2019.
[51] T. Edwards and G. Field, The Relationship Between Speed Humps and Traffic Flow in Mixed Residential Areas, Transportation Research Record, 2022.
[52] Milligan and P. Jenkins, Comparative Analysis of Speed Control Measures: A Study of Developing Nations, International Journal of Urban Transportation Research, 2017.
[53] M. Haider, F. Kamal, and J. Osei, Traffic Calming Techniques: A Global Perspective on Implementation and Outcomes, Transportation Research Part D: Transport and Environment, 2020

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

http://annals.fih.upt.ro