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SPOT SPEED LIMIT STUDIES OF AGAIE-KATCHA-BARO ROAD AGAIE, NIGER STATE

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ABSTRACT

The number of accidents in Nigeria increases relatively from year to year, despite the fact that there are many programs organized by the authority to reduce them. Several factors contribute to the occurrence of accidents. Some of which are human behavior, vehicles condition, weather conditions, road surfaces, and road alignments (vertical and horizontal curves). This research presents empirical research to estimate the 85th percentile operating speed limits. The speed data were obtained using a stopwatch on the selected location along the Agaie-Katcha-Baro Road Agaie, Niger State. Spot speed study was adopted as the method for the research. The method has successfully predicted the 85th percentile speed limit for the Agaie-Katcha-Baro Road Agaie, Niger State. It has established maximum and minimum speed limits for the road and has also shown how inexpensive and quick the stopwatch method is in conducting spot speed studies in Nigerian roads. The findings are hoped to provide a lasting solution towards the national design standard for the highway designer and planner to improving the consistency of geometric design elements of the two-lane highways.

Keywords: 85th Percentile Speed, Accident, Road surface conditions, Spot speed limit.

INTRODUCTION:

Road speed limits are used to set the legal maximum or minimum speed at which road vehicles may travel on a given stretch of road. It is mostly established to improve road traffic safety and reduce the number of casualties from traffic collisions. Procedures used to set speed limits have evolved through years of experience and research. Most states and localities set speed limits for streets and highways based on the results of an engineering and traffic investigation (Taylor *et al.*, 2007; McFadden *et al*., 2001; Najjar *et al*., 2000; Agent *et al.*, 1998; Issa *et al*., 1998). Speed percentiles are the tools used to determine effective and adequate speed limits. In the United States, speed zoning is generally based on the principle of setting speed limits as near as practicable to the speed at or below which 85 percent of drivers are traveling. The 85th percentile of speed (V85) is normally assumed to be the highest safe speed for a roadway section (Agent *et al.*, 1998; Homburger *et al*., 1996). In this case, setting the speed limits at V85 appears to be the safest method because it reduces speed differentials (Najjar *et al*., 2000; Agent *et al*., 1998). When the posted speed (PS) limit is below V85, few drivers will obey the PS limits. Such speed differentials may result in increased accidents (Najjar *et al*., 2000). Speed measurements are most often taken at a point (or a short segment) of the roadway under conditions of free flow. The intent is to determine the speeds that drivers select, unaffected by the existence of congestion. This information is used to determine general speed trends, to help determine reasonable speed limits. Such studies are referred to as "spot speed studies" because the focus is on the selected "spot," or location, on a facility. Spot speed studies are conducted to estimate the distribution of speeds of vehicles in a stream of traffic at a particular location on a highway.

The ability to predict accurate vehicular operating speeds is useful for evaluating the planning, design, traffic operations, and safety of roadways (McFadden *et al*., 2001). The AASHTO design guide (2001) directly relates the design speed with the horizontal and vertical curvature, the maximum superelevation rate, and the sight distance. Other design components, like the lane and shoulder widths, are not directly related to the design speed. They are considered factors of operating speeds. The AASHTO guide suggests that the operating speed depends upon the capabilities of the drivers and the vehicles, the physical highway characteristics, the amount of roadside interference, the weather, the presence of other vehicles, and the speed limitations established by law or traffic control devices. The AASHTO guide recommends that the selection of the design speed should take into consideration the topography, the anticipated operating speed, the adjacent land use, and the highway functional classification. Fitzpatrick *et al*. (1997) found out that the most considered factors used by transportation agencies in the United States when selecting design speeds are: urban vs rural environment, functional class, traffic volume, construction costs, corridor consistency, and the agency's design criteria. The study also found that more than 75 percent of the agencies agreed that the expected operating speed on the highway should also be considered when selecting a design speed. This study is framed to establish a spot speed limit for Agaie-Katcha-Baro Road Agaie, Niger State.

MATERIALS AND METHODS

Description of the study area

Agaie town is the capital of Agaie local government located in Niger State. The Agaie-Katcha-Baro Road Agaie is a two-way highway. The road leads to Baro, a town in Agaie, Niger State which may soon become northern Nigeria's next big commercial center because of the inland water port which was recently inaugurated by the Federal Republic of Nigeria. Baro's port served as a trade link between the North and other parts of the country ferrying goods across the river down to Asaba in the 1960s. The road which is undergoing rehabilitation is some parts and construction in the other parts has started generating much traffic. The route number is A124 with an approximate length of 51.8km. It has a latitude of 9°01'53.37" N and a longitude of 6°24'43.44" E. Since the road is situated close to school and it is very busy, this makes the road to be prone to accidents. The road under investigation is a trunk A road that links northern Nigeria to the western part. The number of vehicles plying the road increases at a tremendous rate so does the accident potential, thus, necessitate this study.

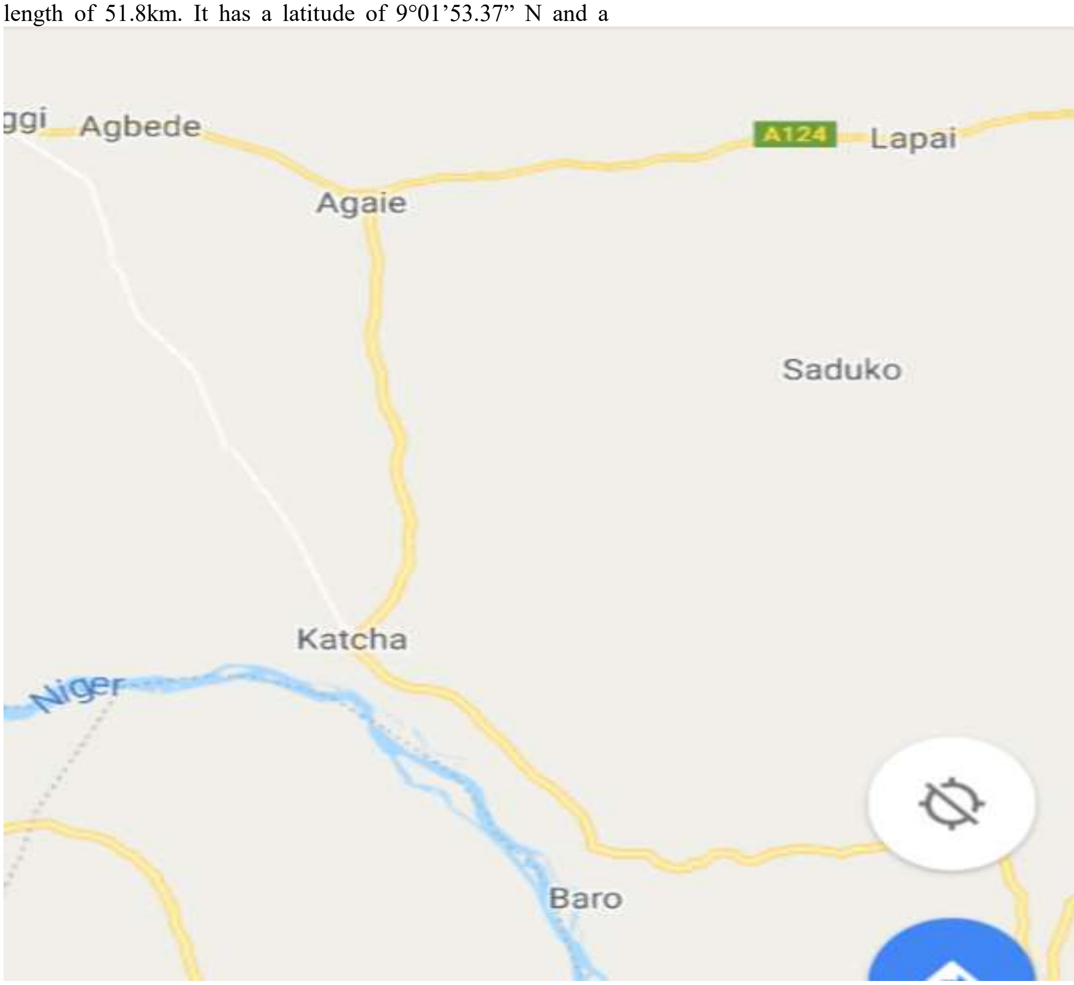

Figure 1.0: Geographical Map of the Study Area (Google Map 2019)

DATA COLLECTION

The stopwatch method was employed in this study which can be used to complete a spot speed study using a small sample size taken over a relatively short period of time. The stopwatch method is a quick and inexpensive method for collecting speed data. Minimum two observers are to collect the data, of which one stands at the starting point to start and stop the stopwatch and the other one stands at the endpoint to give an indication to stop the watch when a vehicle passes the end line.

RESULTS AND DISCUSSION

Table 1.0: Descriptive Statistics Of Vehicles Spot Speed

	LOCATION A	LOCATION B	LOCATION C
Mean (km/h)	67.67	60.33	60.83
Standard Error(km/h)	2.43	1.97	2.27
Median(km/h)	67.50	57.50	62.50
Mode(km/h)	62.50	52.50	57.50
Standard Deviation(km/h)	13.29	10.80	12.44
Sample Variance	176.70	116.70	154.71

Kurtosis	-0.42	1.93	0.89
Skewness	0.48	1.49	0.92
Range	50.00	45.00	50.00
Min. Speed(km/h)	47.50	47.50	47.50
Max. Speed(km/h)	97.50	92.50	97.50

Table 1 revealed that LOCATION A has the highest average spot speed of 67.67 km/h, followed by LOCATION C, while LOCATION B has 60.33 km/h. The high average vehicular traffic spot speed on LOCATION A is attributed to its relatively low traffic volume and possibly better pavement conditions and geometrical features as observed during the fieldwork. According to research conducted by (Maksid and Hamsa, 2014), they found that the speed of vehicles is highly influenced by the geometrical design features of the highway. Their results indicated that vehicles tend to travel faster on relatively straight road stretches than on curve portions. Hence, concluded that for the effective arrest of the vehicles' speeds along arterial roads, a curve alignment should be introduced. It was also identified in another study by Collins (2008) that, on average, drivers would drive fast on a straight open road, followed by a straight road in bad weather, a bendy open road, a bendy road in bad weather, a straight road in the dark and, finally, a closed bendy road. Also, the route along LOCATION A has a relatively high standard deviation of 13.29 km/h which indicates a significant spread of data points over the range of data obtained. The spread of data points on the other highways is within a relatively closer range (about 10.0 – 12.0 km/h) with an average spot speed measuring between 60 – 64 km/h. Figures 2(a), 2(b), and 2(c) showed a histogram plot of vehicular traffic spot speeds for the three locations.

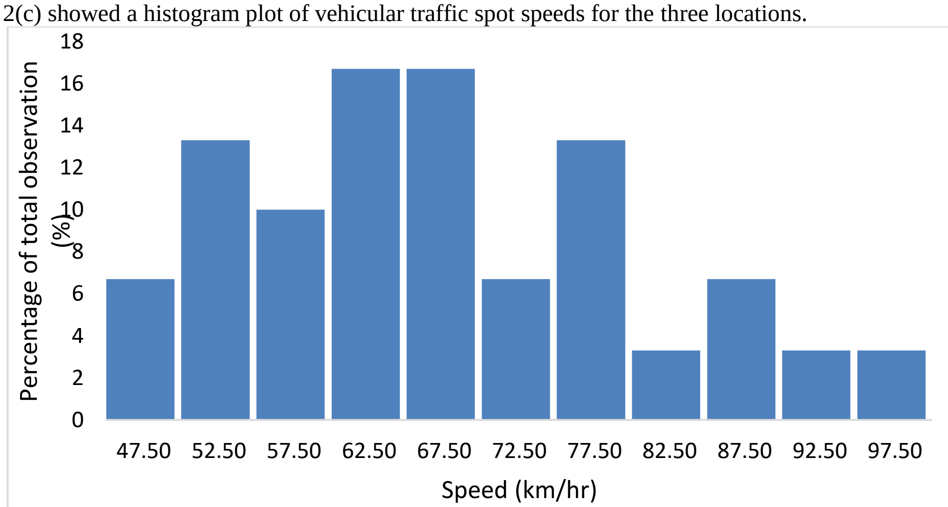

Figure (2a): Location A

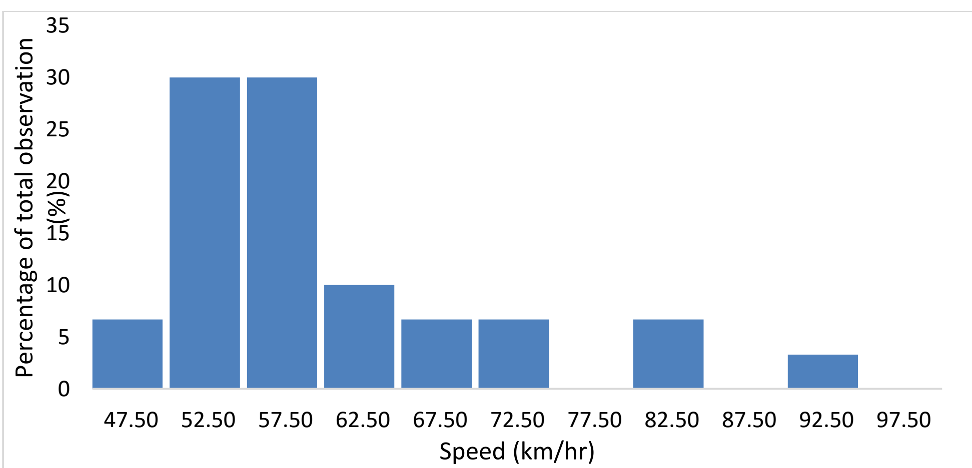

Figure (2b): Location B

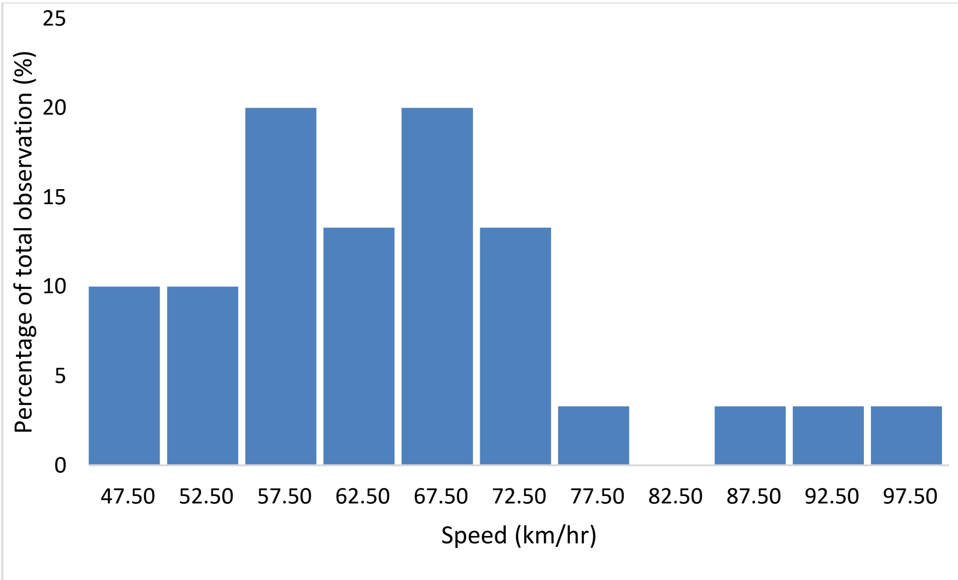

Figure (2c): Location C

The modal spot speeds are deduced from histogram plots as the longest bar for each highway location. Figure 2 revealed that the three locations have modal spot speed within the range of 52 – 67 km/h. Location A road has a relatively high modal spot speed within the range of 62.5 – 67.5 km/h. Corresponding statistical measures of dispersion of vehicular traffic spot speeds on highways in the locations were further examined using superimposed spot speed distribution plots as shown in Figures 3: a,b, and c.

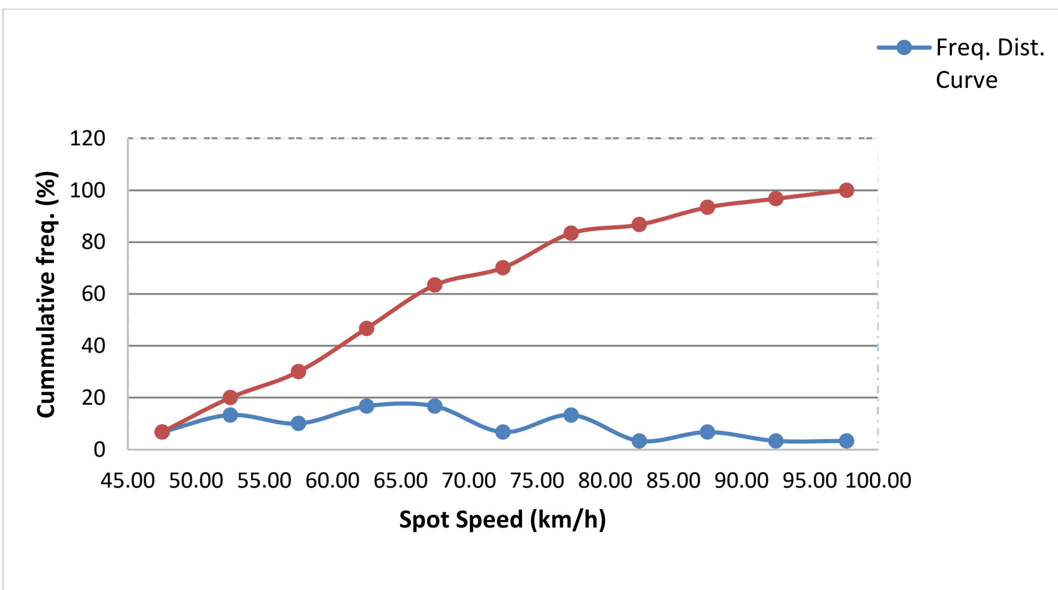

Figure (3a): Location A

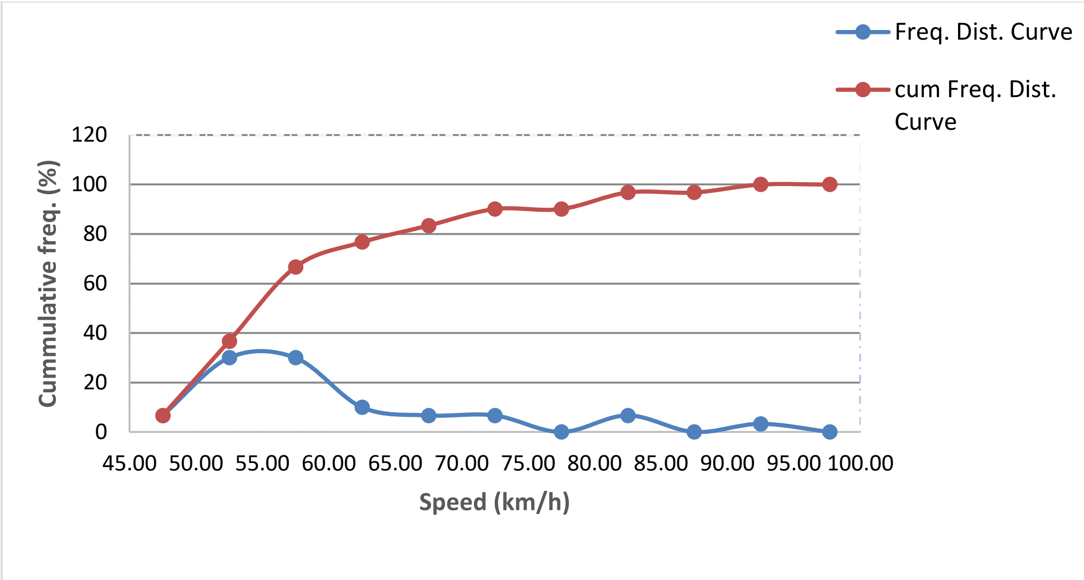

Figure (3b): location B

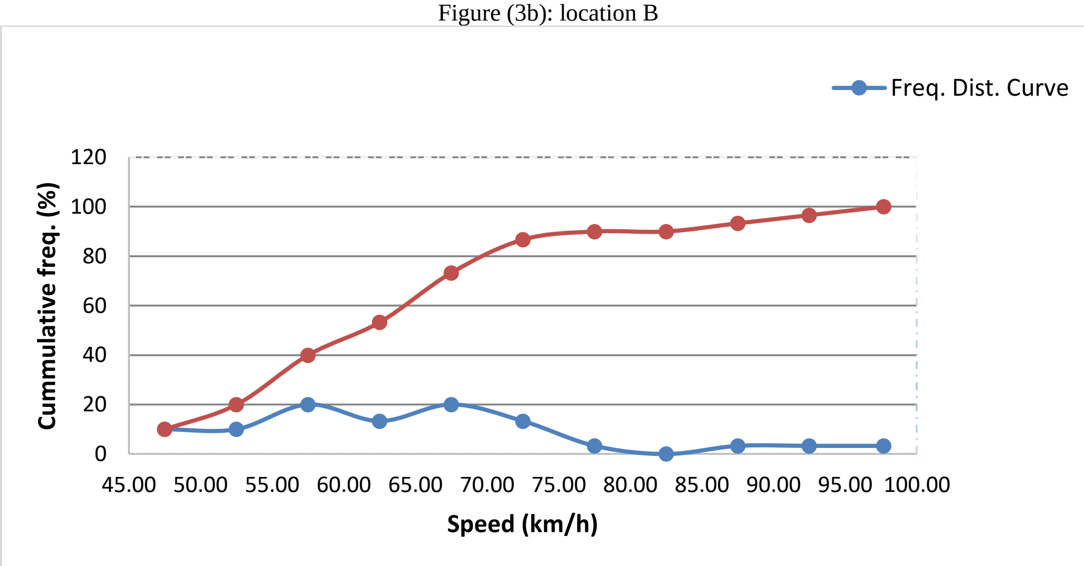

Figure (3c): Location C

From figures 3a,b, and c, it can be seen that the speed distribution from all the locations is not normally distributed, which indicated the presence of shockwaves in the traffic stream. This might be due to the presence of slow and at the same time fast-moving vehicles in the traffic stream that result in the shockwaves.

The Federal Road Safety Commission of Nigeria FRSC (2008) pegged 50km/h as the speed limits for cities in Nigeria. But previous studies like (Adeke, 2011) shows that most operating speed of vehicles in Makurdi, Benue State were above 50km/hr, which conformed with the results obtained in this study at all the locations in Niger state. This indicates that most drivers plying roads in cities were operating above the stipulated speed limits, which indicates a lack of safety culture by the drivers as was stated by (Farouq *et al.*, 2017). To this end, it should be highlighted that proper speed monitoring efforts be emphasized to improve safety on our roads. According to research conducted by (Hany *et al.*, 2017), driver's behavior towards speed limit compliance was found to be highly influenced and affected by the presence of speed management devices (speed camera, speed radar, speed limit signs, enforcement police, etc). There was a drastic reduction in the speed of vehicles as compared to before the full implementation of the speed management devices. It shows the importance of speed monitoring efforts to improve safety on the road (Arintono, 2019).

The current speed limit of 50km/h pegged by the Federal Road Safety Commission of Nigeria (FRSC) is considered low compared to the 85th percentile speed obtained for both locations in this study. Thus, the 85th percentile speed could be used as a guideline in revisiting and determining a new speed limit on these routes because it is assumed to be the highest safe speed for roadway sections under ideal conditions which are used to impose speed limits.

Although this study was carried out successfully, the data collected can not be said entirely correct due to human error and the actions of some drivers. Instead of driving at their normal speed, some drivers slow down upon sighting people employed to take readings. Hence, making it practically impossible to accurately get the exact vehicle spot speeds at those locations. Using some expensive instruments like radar guns could increase the accuracy of the 85th percentile speed estimates as the instrument could be used simply without drivers noticing personnel working at those stretches, thereby eliminating the driver's effect of slowing down at those locations.

Table 2: Speed Data Result Summary from the above histograms of the observed spot speed and spot speed distribution curves of vehicular traffic on Agaie-Katcha-Baro Road, Agaie.

	Speed Limits (km/h)	Mean Speed (km/h)	Standard Deviation (km/h)	Pace (km/h)
Spot A	77.50	67.67	13.29	62.50-68.00
Spot B	68.00	60.33	10.80	52.50-58.00
Spot C	72.00	60.83	12.44	50.00-61.00

CONCLUSIONS AND RECOMMENDATION

CONCLUSIONS

From the foregoing study, it could be seen that the analysis of the spot speed data collected shows no significant differences in the mean speeds of vehicles traveling at various locations where the studies were conducted. It was also observed that the prevailing operating speed of vehicles at all study sites exceeds the design speed limit of 50km/h. The high percentages of driver non-compliance with speed limits require that speed limit enforcement be actively increased.

The 85th percentile speeds at spot A, B, and C were 77.50km/hr, 68.80km/hr, and 72.00km/hr respectively, indicating poor compliance to the pegged speed limit of 50km/h at both spots, thus posing an accident risk within the study areas. In order to guarantee the safety of motorists and pedestrians traversing these routes, the current speed limit should be revisited to determine an appropriate speed limit based on the 85th percentile vehicular speed obtained in this study. The standard deviation at various spots was 13.29km/h at spot A, 10.80km/h at spot B, and 12.44km/h at spot C. The modal speeds at spot A were 62.50km/h and 67.50km/h, 52.50km/h and 57.50km/h at spot B and 57.50km/h and 67.50km/h at spot C respectively.

Looking at the trend in table 2, we could notice that the mean speed for the vehicles at both stations was higher (+10 km/h) than the designed speed limit. It could be observed that at Spot A, the mean speed was 67.67km/h. Spot B has a 60.33km/h mean speed, while Spot C's mean speed observed was 60.83km/h.

The established maximum and minimum speed limits in this study were 68.00km/h and 62.50km/h respectively. Finally, it could be concluded that the use of the stopwatch method to conduct spot speed studies in characterizing speed distribution in Nigerian roads has proven to be a quick and inexpensive method.

RECOMMENDATION

It is recommended that the 85th percentile speed acquired from this study be employed to set the legal speed limit on Agaie-Katcha-Baro Road, in Agaie, Niger State, so that crash rates can be properly managed and minimized.

And further research should focus on assessing speed as a contributor to vehicle crashes on this road

REFERENCES:

AASHTO. (2001). Manual design guide for higway.

Abubakar, I. (2014). *The Use of Spot Speed Study to Establish No-Passing Zones on a Two Lane Highway.* Department of Civil Engineering, A.B.U. Zaria.

Adeke. (2011). *Vehicular traffic volume counts and spot speed.* Makurdi.

Agent, K., Pgman, J., & Weber, J. (1998). Evaluation of Speed Limits in Kentucky. *Journal of Transportation Research Records* , No. 1541, PP. 57-64.

Akmal, A. (2015). *Trends and Causes of Traffic Accidents. A Selection Dilemma of Transportation System Engineering.* Dubai.

Aminu, B. (2017). *Development of Speed Limits Model for Felele Road Lokoja, Kogi.* Department of Civil Engineering, Ahmadu Bello Unibersity, Zaria.

Basheer, I., & Najjar, Y. (1996). A Neural Network-Based Distress Model for Kansas JPCP Longitudinal Joints. *Intelligent Engineering System Through Artificial Neural Networks* , Vol.6, pp. 983-988.

Ben-Arieh, D., Chang, S., Rys, M., & Zhang, G. (2004). Gometric Modelling of Roadways Using Global Positioning System Data and B-spline Approximation. *Journal of Transportation Engineering* , 130(5), 632-636.

Brewer, M., Pesti, G., & Schneider, W. (2006). Improving Compliance with Work Zone. *Transportation Research Board* , No. 1948, PP. 67-76.

Cardoso, J., Kabbach-Junior, F., & Suzuki, C. (2000). Analisis of Speed Prediction for Design Consistency of Two-Lane Rural Highways. *In 4th International Symposium on Highway Geometric Design* .

Carlson, M., Fitzpatrick, p., Brewer, M., & Wooldridge. (2003). Design Speed, and Posted Speed Practice. *NCHRP Report* , 504.

Donald, D., & Caimey, P. (2004). Higher Open Road Speed Limit. *An Objective Assessment* , No. 298.

Emma Collins (2008), Rural road safety – a question of speed?, *Transport Research Institute*, Napier University

Ewing, R. (1999). Traffic Calming Impacts. *Institute of Transportation Engineers* , PP. 99-126.

Farouq, M. M., Anwar, F. H., Baba, Z. B., Labbo, M. S., & Aliyu, D. S. (2017). Road Maintenance

Federal Republic of Nigeria (2013). *Highway Manual Part 1: Design, Geometric Design*, Nigeria.

Management in Kano State, Nigeria: . *Journal of Mechanical and Civil Engineering (IOSR-JMCE)* , 50-62 DOI: 10.9790/1684-1403035062.

Fitzpatrick. (1997). Design Manual Guide.

Garber, J., & Hoel, A. (2009). *Traffic and Highway Engineering.* Virginia: Univewrsity of Virginia.

Gonet, H. M. (2007). *Design Consitency of Horizontal Alignments on.* Addis Ababa.

H. Hany, M. Shawky, and M.K. Mohamed (2017), Investigation of Driver's Behavior towards Speeds using Crash Data and Self-Reported Questionnaire. *Accident Analysis and Prevention*, Vol 98, pp 348-358

Homburger, W., Hall, J., Loutzenheiser, R., W.R., & Reilly. (1996). *Spot Speed Studies. In Fundamentals of Traffic Engineering.* Berkeley: Institute of Transportation Studies.

INDOT. (1992). *Design Manual.*

Issa, R., Zaman, M., & Najjar, Y. (1998). Modeling the 85th Percentile Speed on Oklahoma Two-Lane Rural Highways: A Neural Network Approach. *Final Report submitted to Oklahoma Department of Transportation (ODOT)* , project No. 6007; ORA 125-5227.

Javid, & Shahid. (2011). *Spot speed study.*

Kadri, T. (2015). *Spot Speed Studies; A Case Study of Airport Road Abuja.* Department of Civil Engineering Ahmadu Bello University, Zaria.

Knoblauch, R., Pietrucha, M., & Nitzberg, M. (2006). Field Studies of pedestrian Walking Speed and Start-Up Time. *Transportation Research Board* , No. 1538, PP. 27-38.

Knowles, V., Persaud, B., & Parker, M. (1997). *Safety,Speed and Speed Management.* Ottawa: A Canadian Review.

Lamm, R., & Choueiri, E. (1987). Recommendations for Evaluating Horizontal Design Consistency Based Investigations in the State of New York. *Transportation Research Record, Washington, DC* .

Mattox, J., Sarasua, J., Ogle, R., Eckenrode, & Dunning, A. (2007). Development and Evaluation of Speed-Activated Sign to Reduce Speed in Work Zones. *Transportation Research Board* , No. 2015. PP. 3-11.

McFadden, J., Yang, W., & Durranc, S. (2001). Application of Artificial Neural Network to Predict Speeds on Two-Lane Rural Highways. *Journal of Transportation Research Record* , No. 1751, PP. 20-27.

McFadden, J., Yang, W., & Durranc, S. (2001). Application of Artificial Neural Network to Predict Speeds on Two-Lane Rural Highways. *Journal of Transportation Research Record, No.* , 1751, pp. 20-27.

Memon, R., & Khaskheli, G. Q. (2008). Operating Speed Models for Two-Lane Rural Roads in pakistan. *Canadian Journal Civil Engineering* , Vol.35, 443-453.

Misaghi, P., & Hassan, Y. (2005). Modeling Operating Speed and Speed Differential on Two-Lane Rural HIghways. *Journal of Transportation* , 131(6), 408-417.

MUTS. (2001). *Highway desin manual.*

Najjar, Y., Basheer, I., & McReynolds, R. (1996). Neural Modeling of Kansas Soil Swelling. *Journal of Transportation Research Record* , No. 1526, pp. 14-19.

Najjar, Y., Russell, E., Stokes, R., & Ghassan, A. L. (2002). New Speed Limits on Kansas Highways: Impact on Crashes and Fatalities. *Journal of the Transportation Research Forum* , Vol. 56, No.4, pp.119-147.

Najjar, Y., Stokes, R., & Russell, E. (2000). Setting Speed Limits on Kansas Two Lane Highways. *Journal of Transportation Research Record* , NO. 1708, PP. 20-27.

Najjar, Y., Stokes, R., & Russell, E. (1999). Using Roadway Characteristics to Set Reasonable Speed Limits on Kansas

Two-Lane Rural Roads. *Intelligent Engineering System through Artificial Neural Network* , Vol. 9, pp. 833-838.

Nehate, G., & Rys, M. (2006). 3D Calculation of Stopping-Sight Distance fro GPS Data. *Journal of Transportation Engineering* , 132(9), 691-698.

Nicholas. (2009). *Design Manual Guide.*

Noor Hafiza Mohd Maksid and Abdul Azeez Kadar Hamsa (2014), Evaluating The Effects Of Road Geometrical Design Towards Spot Speed Distribution On Arterial Road. PLANNING MALAYSIA: *Urban Planning and Local Governance* Vol 3, Pp 111- 126

Oflaherty, C. (1997). *Highways and Traffic Volumes: Volume. 1*. London.

Parker, M. (1985). Synthesis of Speed Zoning Practices. *Federal Highway Administration* .

Rilwan, B. (2015). *Spot Speed Studies A Case Study of Zaria-Kaduna Expressway.* Department of Civil Engineering, Ahmadu Bello University, Zaria.

Roger. (2004). *Standard Handbook for Civil Engineers.* New York: 5th Edition.

S. Arintono (2019), Spot Speed versus Speed Limit on Malaysian East-Coast Expressway.

Journal of Science and Applied Engineering (JSAE), Vol 2 (1), pp 17-21

Salter, R. (1976). *Highway Traffic Analysis and Design.* London: Macmillan.

Simpson, P. (1990). *Artificial Neural Systems: Foundations, Paradigm, Application, and Implementations.* New York: Pergamon Press.

Solomon, D. (1964). *Accident on Main Rural Highway Relatesd to Speed, Drivers and Vehicles.* Technical Report U.S Department of Commerce Bureau of Public Works.

Tarefder, R., White, L., & and Zaman, M. (2005). Neural Network Model for Asphalt Concrete Permeability. *Journal of Materials in Civil Engineering,* , Vol. 17, No.1, pp.19-27.

Taylor, D., Mutiah, S., Kulakowski, B., Mahony, K., & and Porter, R. (200). Artificial Neural Network Speed Profile Modek for Construction Work Zones on High-Speed Highways. *Journal of Transportation Engineering* , pp. 198-204.

Voigt, A., Stevens, C., & Borchardt, D. (2008). Dual-Advisory Speed Signing on Freeway-to-Freeway Connectors in Texas. *Transportation Research Board* , No. 2056, PP. 87-94.

Zaman, M., Issa, R., & Najjar, Y. (2000). Modelling the 85th Percentile Speed on Oklahoma Two-Lane Rural Highways Via Neural Network Approach. *Computational Intelligence Applications in Pavement and Geotechnical Systems, Attoh-Okine (Editor)* , pp. 99-108.

Zaman, M., Solanki, P., Ebrahimi, A., & White, L. (2010). Neural Network Modeling of Resilient Modulus Using Routine Subgrade Soil Properties. *International Journal of Geomechanics* , Vol. 10, No.1, pp. 1-12.

Zupan, J., & Gasteiger, J. (1993). *1993)."Neural Network for Chemists: An Introduction.* New York: VCH.