

DEVELOPMENT OF A GPS-GIS-BASED ROAD SIGNAGE MANAGEMENT SYSTEM FOR SELECTED ARTERIAL ROADS

O. O. Adeleke^{a*}, K. O. Akande^a, S. S. Kolo^b, J. O. Odumosu^c, O. O. Sijuwola^a, A. M. Ayanshola^d

^aDepartment of Civil Engineering, University of Ilorin, Ilorin, Nigeria

^bDepartment of Civil Engineering, Federal University of Technology, Minna, Nigeria

^cDepartment of Surveying and Geoinformatics, Federal University of Technology, Minna, Nigeria

^dDepartment of Water Resources and Environmental Engineering, University of Ilorin, Ilorin, Nigeria

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*Corresponding author
adeleke.oo@unilorin.edu.ng



Abstract

Traffic signs, pavement markings and other road safety assets such as speed bumps are provided on roadway facilities to enhance traffic flow and safety. They will however perform their functions effectively if they meet the basic requirements of i. fulfill a need ii. command attention iii. convey a clear simple meaning iv. command respect from road users and v. give adequate time for proper response. It is noticed and rightfully observed by the Nigeria National Council on Works that these assets on Nigeria roads are not adequately managed and maintained. Some of them are not well positioned, some are missing and some others are damaged. There is therefore the need to assess the existing roadway assets, their conditions and adequacy, and generate a database needed for their effective operation, management and maintenance. The study thus aims at addressing the observed inadequacies by proffering a GPS-GIS-based solution. The objectives are to i. carry out an inventory of existing road signs and markings; ii. determine their adequacy or otherwise and iii. develop a GIS- based road signage management system. It is anticipated that the application of the developed system will enhance the performance of the agencies responsible for the operations of the road assets.

Keywords: GIS, safety, signage management, traffic flow, traffic sign defects

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1.0 INTRODUCTION

1.1 Background to the Study

Traffic road signs, pavement markings and other road safety assets such as speed bumps are very useful on fixed facility as they display to road users what to do, what to watch for and where to drive; resulting to smoother traffic flow, reduced fuel consumption, improved roadway capacity and reduced collision rate (Federal Ministry of Works, 2013; McGee, 2010; Pour-Rouholamin and Zhou 2016). The functionality of road signs and markings however, depends on their visibility and recognition during day time and night time. This calls for their

adequate placement, management and maintenance (Yannis et. al., 2014). However, the sheer size of these assets can be enormous which poses a great challenge and demand on agencies saddled with their operations, which sometimes incapacitates their adequate maintenance. In Ilorin metropolis of Nigeria as it is also the case in some other urban centres in Nigeria, these road assets are noticed not to be adequately performing their basic functions of warning, guiding and providing information to road users as needful because some of them are defaced while others are damaged and need replacements (Nigerian National Council on Works (NNCW), 2017). Coupled with these are observed faded pavement markings on the city road network. Also noticeable is inadequate placement of some of these road assets. These

deficiencies result to increased hazardous environment and travel risk for road users which sometimes lead to accidents. Accurate data on the locations, attributes and conditions of the traffic assets are important as they serve as the basis for cost efficient and compliance effective maintenance and management strategies (Migletz et. al., 1994; Boggs et. al., 2013). In the bid to improve on the operations, management and maintenance of these assets which require adequate and well managed data on their locations, attributes and conditions, the combination of Global Positioning System (GPS) and Geographic Information System (GIS) technologies are utilised in the study to develop a GPS-GIS-based management system. GPS is a satellite based navigation system that uses signals from satellites to determine the position (latitude and longitude) of a receiver at a location and also provides time information. The GPS provides the location and time information in any weather conditions, in any part of the world, for the entire day. Its area of application includes mapping and navigation (Bhawani, 2014). A GIS is a system of hardware, software and procedures used to facilitate the management, manipulation, analysis, modelling, representation and display of georeferenced or spatial data to solve complex problems regarding planning and management of resources. GIS has emerged as an essential tool for urban and resource planning and facility management among many other applications. Functions of GIS include: data entry, spatial query, data analysis and display, data management and information retrieval (Escobar et. al., 1990; Goodchild and Kemp, 1990). The study aims at addressing the inadequacies associated with the location and maintenance of road signage with a view to proffering a GPS-GIS-based solution to ameliorate the problem. The objectives are to i. carry out an inventory of existing road signs and markings; ii. determine the adequacy or otherwise of existing road signs and markings and iii. develop a GPS-GIS-based road signs management system. This paper presents a pilot study conducted on four roadways in Ilorin metropolis. The study can however be replicated on wider geographic area.

1.2 Study Area

Four primary arterial roads in Ilorin metropolis, Kwara State, Nigeria are selected for the study. The roads are Ibrahim Taiwo road, Unity road, Murtala Mohammed road and University of Ilorin Main Campus road.

1.3 Literature Review

Traffic signs can be grouped into several types. For example, Annex 1 of the Vienna Convention on Road Signs and Signals (United Nations, 1968), which on 30 June 2004 had 52 signatory countries, defines eight categories of signs: i. Danger warning signs ii. Priority signs iii. Prohibitory or restrictive signs iv. Mandatory signs v. Special regulation signs vi. Information, facilities, or service signs vii. Direction, position, or indication signs and viii. Additional panels. Traffic signs are also however functionally classified into three broad groups as i. regulatory signs ii. warning signs and iii. guide signs (Alberta Infrastructure and Transportation, 2006). Accurate understanding is a dominant factor for the effectiveness of a traffic sign system. With poor comprehension, memory for sign meanings and the likelihood of prompting effective driver reactions will decrease (Charlton, 2006). Lack of comprehension or misunderstanding

of the message from these signs can cause negative consequences which may contribute to operational and safety problems (Government of Alberta, 2005; Ogden, Womack and Mounce, 1990; Ng and Chan, 2008). In order for traffic signs to be effective, they should meet the following basic requirements: 1. Fulfill a need, 2. Command attention, 3. Convey a clear, simple meaning, 4. Command respect from road users and 5. Give adequate time for proper response (Federal Highway Administration, 2009). Road surface marking is any kind of device or material that is used on a road surface in order to convey official information. They are used on paved roadways to provide guidance and information to drivers and pedestrians (Texas Dept. of Transp., 2004; Pour-Rouholamin and Zhou, 2016). Uniformity of the markings is an important factor in minimizing confusion and uncertainty about their meaning, and efforts exist to standardize such markings across borders (United Nations, 1968). However, countries and areas categorize and specify road surface markings in different ways. Traffic marking performance can be evaluated under factors such as; general daylight appearance, color, film condition, bead retention, and reflectance. Several materials can be used for pavement markings. However, the performance and cost for each material may vary greatly depending on a number of factors, such as traffic volume, surface type, climatic condition and project duration (Praprut and Adam, 2011; Ozelim and Turochy, 2014). The most popularly used pavement marking materials are paint, thermoplastics, epoxy and polyuria (Texas Dept. of Transp., 2004; Rahman and Duggal, 2015). The popularly used material for pavement marking in Nigeria is thermoplastic paint (Punch, 2019). The performances of these marking materials are measured in terms of their durability, retro-reflectivity, and skid resistance. Durability refers to the amount of material remaining on the pavement surface over time and it affects both the day time and night time appearance of marking. In an effort to effectively manage traffic signs, some agencies and municipalities have developed GIS-based management systems of traffic signs examples include Kenya (Kiema and Mwangi, 2009) and Uttarakhand (Pandeh and Joshi, 2011).

2.0 MATERIALS AND METHODS

2.1 Data Collection

Primary and secondary data were used in building the signage inventory.

2.1.1 Primary Data

2.1.1.1 Non Spatial Data

The non spatial attribute and condition data used in the database were obtained through a visit to the study area and direct observation of the traffic signs, pavement markings and safety assets with the aid of camera and video coverage to capture them. Visual day time and night time physical condition inspections of the signs, pavement markings and safety assets were carried out manually to identify any deficiencies which impact visibility and legibility thus determining their functionality. The sign type, material used for the sign, the height, shape, color, positioning, photographs and adequacy of

the traffic safety facilities were obtained and assessed. Tape was used to measure the heights as appropriate.

2.1.1.2 Spatial Data

The GPS was used to capture the coordinates of the locations of all the exiting traffic signs in the study area.

2.1.1.3 Sign Condition Assessment

The sign condition assessment data was used to rate and classify the traffic signs into: CRITICAL – sign needs immediate replacement or repair to restore performance to the desired level; FAIR – sign that may need replacement within six months to five years and GOOD – sign that may need replacement in five or more years. The date and time of inspections and inspectors' names, weather conditions were also captured for future reference.

2.1.2 Secondary Data

The secondary data used for this project was an existing road map of the study area which was digitized and georeferenced.

2.2 Importation of the Collected Data into GIS Software and Data Analysis

The data collected was used to build the sign inventory database. A folder was created for the collected attribute data of the features; the data was prepared in Microsoft Excel and imported into the ArcGIS10.3.1 through the tools on the interface. The data was then converted into shape file and added to the georeferenced line features (road network) through the Add data (+) on the interface to form the database.

The ArcGIS was thereafter used among other things to map out the critical, fair and good traffic signs. Arc Catalog was used to store the point data and their corresponding attributes. The Facility feature class is broken down into separate feature classes for the purpose of analysis.

3.0 RESULTS AND DISCUSSION

3.1 Road Inventory

3.1.1 Unity Road

Unity Road is a dual carriage road which is overlaid with flexible bituminous surfacing material. The road is 1.02 km long. The median width ranges between 0.4 to 0.6 m. Lined drain runs along the edges of this fixed facility with width ranging from 0.6 to 0.9 m. The major intersection along this road is Obbo road junction, Coca-Cola road junction and Irewolede junction. There is also a market adjacent to the road at Obbo road junction. All vehicle types are used on this road. Nevertheless, the road does not have pavement markings; neither lane markings, pedestrian crossings nor stoplines at intersections where appropriate. There are eleven traffic signs along the road. The traffic signs are mounted at a height of 2.5 m from ground elevation which is in accordance to Federal Ministry of Works (2013) specification. The sign inventory is shown in Table 1. The table shows the coordinates, the post condition, the sign defect, the material used for the traffic signs, the information portrayed by each traffic sign and the shape of each traffic sign. This helps the traffic signs management personnel to have required and adequate details on each traffic sign. This is similarly done for the other studied roads as shown in Sections 3.1.2 – 3.1.4

Table 1 Data obtained on Unity Road

Sign/Post ID Number	Sign Street Name	Sign Position	Latitude	Longitude	Post Material	Post Type	Sign Category	Mou nt Height (m)	Sign Defect	Sign/P ost Condition
1	Unity Road	Right	8°28'50.30"N	4°33'44.84"E	Steel	Railway Post	Information	2.7	NIL	Good
2	Unity Road	Right	8°28'50.18"N	4°33'44.92"E	Steel	Round	Information	2.5	NIL	Good
3	Unity Road	Center	8°28'49.91"N	4°33'44.44"E	Steel	Round	Information	2.6	NIL	Good
4	Unity Road	Center	8°28'49.05"N	4°33'44.92"E	Steel	Round	Information	2.5	NIL	Good
5	Unity Road	Left	8°28'48.78"N	4°33'44.40"E	Steel	Round	Information	2.5	NIL	Good
6	Unity Road	Left	8°28'49.09"N	4°33'43.65"E	Steel	Square	Regulatory	2.5	NIL	Good
7	Unity Road	Centre	8°28'49.87"N	4°33'40.07"E	Steel	Round	Information	2.5	NIL	Good
8	Unity Road	Left	8°28'49.60"N	4°33'39.84"E	Steel	Round	Regulatory	2.5	NIL	Good
9	Unity Road	Right	8°28'50.03"N	4°33'39.95"E	Steel	Round	Warning	2.5	Low visibility	Fair
10	Unity Road	Right	8°28'50.10"N	4°33'38.97"E	Steel	Round	Information	2.5	Low visibility	Fair
11	Unity Road	Left	8°28'49.68"N	4°33'39.17"E	Steel	Round	Information	2.5	NIL	Good

3.1.2 Ibrahim Taiwo Road

Ibrahim Taiwo Road is a 3.17 km long dual carriageway overlaid by a flexible bituminous surfacing material with double lanes in each direction. The median width ranges between 0.4 to 0.6 m

with street-light within. Lined drains run along the edges of this fixed facility with width ranging from 0.6 to 0.9 m. All vehicle types are used on this road. The major intersections along the road include Oro road junction and Oko-erin junction. The road does not have pavement markings. The road has five traffic

signs. The traffic signs are mounted at a height of 2.0 m from ground elevation, which is within the range of traffic sign height specified by Federal Ministry of Works (2013). The sign inventory is presented in Table 2.

3.1.3 Murtala Mohammed Road

Murtala Mohammed road has a total length of 10 km. The double lane dual carriageway has shoulders along its sides with bituminous material overlaid on both the shoulders and the carriageway. The drainage system along the edges is covered by slabs to serve as sidewalk for pedestrians. Along the shoulders are road curbs to segregate the carriageway from the sidewalk. The shoulders have width range of 1.5 to 1.6 m. The median width ranges from 0.5 m to 1.0 m with rails along the

median to control road crossing by pedestrians. Major junctions along this road are: Challenge, Post-Office, UBA and Anjorin junctions etc. Challenge intersection is located within 200 m to 300 m from UBA junction. 300m from the Challenge intersection towards Maraba intersection is a fly-over that spans the Post-office intersection. The fly-over has guardrails along the edges for vehicles on it, also white solid edge lines are drawn to inform users of both side restriction and lane crossing; the lane markings on the flyover are observed to have faded. The road has a total number of thirteen traffic signs, with no trace of pavement markings or stoplines at any of its intersections. The traffic signs are mounted at a height of 2.5 m from ground elevation which is in accordance to the Federal Ministry of Works (2013) specification. The sign inventory is presented in Table 3.

Table 2 Data Obtained on Ibrahim Taiwo Road

Sign/Post ID Number	Sign Street Name	Sign Position	Latitude	Longitude	Post Material	Post Type	Sign Category	Mount Height (m)	Sign Defect	Sign/Post Condition
1	Ibrahim Taiwo Road	Left	8°28'57.44"N	4°33'14.38"E	Steel	Not shown	Not shown	2.0	Mounted head removed	Critical
2	Ibrahim Taiwo Road	Left	8°28'57.40"N	4°33'11.74"E	Steel	Not shown	Not shown	2.0	Mounted head removed	Critical
3	Ibrahim Taiwo Road	Right	8°28'57.79"N	4°33'11.86"E	Steel	Round	Information	2.0	Not visible	Critical
4	Ibrahim Taiwo Road	Left	8°28'55.37"N	4°32'47.49"E	Steel	Round	Information	2.0	Not visible	Critical
5	Ibrahim Taiwo Road	Left	8°28'54.05"N	4°32'39.73"E	Steel	Round	Warning	2.0	Not visible	Critical

Table 3 Data Obtained on Murtala Mohammed Road

Sign/Post ID Number	Sign Street Name	Sign Position	Latitude	Longitude	Post Material	Post Type	Sign Category	Mount Height (m)	Sign Defect	Sign/Post Condition
1	Murtala Mohd.Rd	Centre	8°29'57.49"N	4°34'25.71"E	Steel	Round	Information	2.5	NIL	Good
2	Murtala Mohd.Rd	Left	8°29'58.97"N	4°34'27.95"E	Steel	Round	Information	2.5	Not visible	Critical
3	Murtala Mohd.Rd	Right	8°29'55.97"N	4°34'23.50"E	Steel	Round	Warning	2.5	Low visibility	Fair
4	Murtala Mohd.Rd	Centre	8°29'54.34"N	4°34'22.32"E	Steel	Square	Information	2.5	NIL	Good
5	Murtala Mohd.Rd	Left	8°29'49.97"N	4°34'18.78"E	Steel	Square	Information	2.6	NIL	Good
6	Murtala Mohd.Rd	Left	8°29'46.59"N	4°34'15.98"E	Steel	Round	Information	2.5	Not visible	Critical
7	Murtala Mohd.Rd	Right	8°29'36.38"N	4°34'06.49"E	Steel	Round	Information	2.5	Not visible	Critical
8	Murtala Mohd.Rd	Left	8°29'34.28"N	4°34'05.11"E	Steel	Round	Information	2.3	Not visible	Critical
9	Murtala Mohd.Rd	Left	8°29'30.81"N	4°34'01.37"E	Steel	Round	Information	2.5	NIL	Good
10	Murtala Mohd.Rd	Centre	8°29'26.88"N	4°33'56.76"E	Steel	Square	Information	2.5	NIL	Good
11	Murtala Mohd.Rd	Centre	8°29'25.59"N	4°33'55.74"E	Steel	Square	Regulatory	2.5	Low visibility	Fair
12	Murtala Mohd.Rd	Centre	8°29'04.60"N	4°33'48.77"E	Steel	Square	Regulatory	2.5	NIL	Good
13	Murtala Mohd.Rd	Centre	8°29'01.33"N	4°33'48.22"E	Steel	Round	Information	2.5	NIL	Good

3.1.4 University of Ilorin Main Campus Road

The road runs from University of Ilorin main gate to University of Ilorin roundabout (where there is a fountain). It is a 5.36 km 3-lane carriageway of a width of 9.10 m. The road has twenty traffic signs. The traffic signs are mounted at a height of 2.1 m

from ground elevation. It is overlaid by a flexible bituminous surfacing material. The road has fourteen bumps for speed calming. Bump information signs are however not provided for all the bumps nor are they marked with paints. There are also neither lane markings nor stoplines on the entire road length. The sign inventory is presented in Table 4.

Table 4 Data Obtained on University of Ilorin Road

Sign/Post ID Number	Sign Street Name	Sign Position	Latitude	Longitude	Post Material	Post Type	Sign Category	Mount Height (m)	Sign Defect	Sign/Post Condition
1	Unilorin Road	Left	8°28'51.21"N	4°38'15.45"E	Steel	Triangle	Warning	2.0	NIL	Good
2	Unilorin Road	Left	8°28'51.32"N	4°38'29.34"E	Steel	Round	Information	2.1	Not visible	Critical
3	Unilorin Road	Right	8°28'51.00"N	4°38'34.54"E	Steel	Round	Information	2.1	Not visible	Critical
4	Unilorin Road	Right	8°28'50.20"N	4°38'39.71"E	Steel	Round	Information	2.1	NIL	Good
5	Unilorin Road	Right	8°28'44.69"N	4°38'48.10"E	Steel	Round	Information	2.1	Not visible	Critical
6	Unilorin Road	Right	8°28'34.33"N	4°38'52.24"E	Steel	Round	Information	2.1	Not visible	Critical
7	Unilorin Road	Right	8°28'27.62"N	4°38'53.34"E	Steel	Round	Information	2.1	Not visible	Critical
8	Unilorin Road	Right	8°28'20.12"N	4°38'55.03"E	Steel	Round	Information	2.1	Not visible	Critical
9	Unilorin Road	Right	8°28'17.08"N	4°38'56.86"E	Steel	Round	Information	2.1	Not visible	Critical
10	Unilorin Road	Left	8°28'12.22"N	4°39'02.94"E	Steel	Round	Information	2.1	Not visible	Critical
11	Unilorin Road	Right	8°28'09.79"N	4°39'06.86"E	Steel	Round	Information	2.1	Not visible	Critical
12	Unilorin Road	Right	8°28'08.02"N	4°39'10.01"E	Steel	Triangle	Information	2.1	Not visible	Critical
13	Unilorin Road	Left	8°28'06.17"N	4°39'13.63"E	Steel	Round	Information	2.1	Not visible	Critical
14	Unilorin Road	Left	8°28'01.60"N	4°39'21.70"E	Steel	Round	Information	2.1	Not visible	Critical
15	Unilorin Road	Left	8°28'02.55"N	4°39'43.53"E	Steel	Rectangle	Warning	2.1	NIL	Good
16	Unilorin Road	Left	8°28'07.00"N	4°39'47.71"E	Steel	Square	Warning	2.1	Low visibility	Fair
17	Unilorin Road	Right	8°28'25.48"N	4°40'10.25"E	Steel	Round	Warning	2.1	Not visible	Critical
18	Unilorin Road	Right	8°28'23.22"N	4°40'07.10"E	Steel	Round	Warning	2.1	Not visible	Critical
19	Unilorin Road	Left	8°28'24.73"N	4°40'08.48"E	Steel	Triangle	Information	2.1	Not visible	Critical
20	Unilorin Road	Right	8°28'36.42"N	4°40'20.09"E	Steel	Round	Warning	2.1	Not visible	Critical

3.2 Sign Condition

While some of the signs are rated "Good", some others are rated 'Fair' or 'Critical'. Figures 1 and 2 are samples of the

traffic signs rated 'Good' and are located at Chainage (Ch) 0+145m and Ch 0+175m on Unity Road respectively; their letterings and signs symbols are legible and the colors considered as bright.



Figure 1 Signage at 0+145m on Unity Rd



Figure 2 Signage at 0+175m on Unity Rd



Figure 3 Signage at 0+075m on Murtala Moh'd Rd



Figure 4 Signage at 2+081m on University Rd



Figure 5 Signage at 0+052m on Ibrahim Taiwo Rd



Figure 6 Signage at 2+252m on University Rd



Figure 7 Signage at 1+038m on Murtala Mohammed Rd

Signs on Figures 3 and 4 are classified as 'Fair' (maintenance need is futuristic) needing maintenance in the future. Their colors and legibility are already poor and need to be attended to in the very near future. Figure 5 is a signage at Ch 0+052m on Ibrahim Taiwo Road. The sign mounted on the post has been removed and rated as a 'Critical' traffic sign as it is blunt and does not convey any message; therefore needs immediate maintenance. So also is the sign on Figure 6 at Ch 2+252m on University of Ilorin roadway rated 'Critical' sign. Figure 7 is a defaced signage at Ch 1+038m on Murtala Mohammed Road, its condition is classified as critical and needs urgent maintenance.

3.3 Comparison of the Sign Post Factors

Figures 8 – 12 display a comparison in percentages of the different sign post factors between the four studied roads. Figure 4 shows that 81.8 % of the signages along Unity road have no defects while all the signages along Taiwo road have one defect or the other. Forty percent of the sign posts along Taiwo road have their mounted heads removed making it impossible to identify what type of information they are to convey. In Figure 12 all the signages along Taiwo road are 'Critical' whereas 81.8 % of the signages along Unity road are rated 'Good'.

3.3 Database Management

Figure 13 is a display of the traffic signs at Murtala Mohammed Road while Figure 14 shows the signs situated along University of Ilorin Main Campus Road.

The red points represent the 'Critical' signs, the green points represent the 'Good' signs and the purple points represent the 'Fair' traffic signs.

The graphical display of the sign locations assists in the maintenance gang deployment and maintenance schedule. Figures 15 and 16 respectively show the outcome of the spatial search query for the attribute tables of 'Critical' traffic signs on the University Road and the 'Good' traffic signs on the same road.

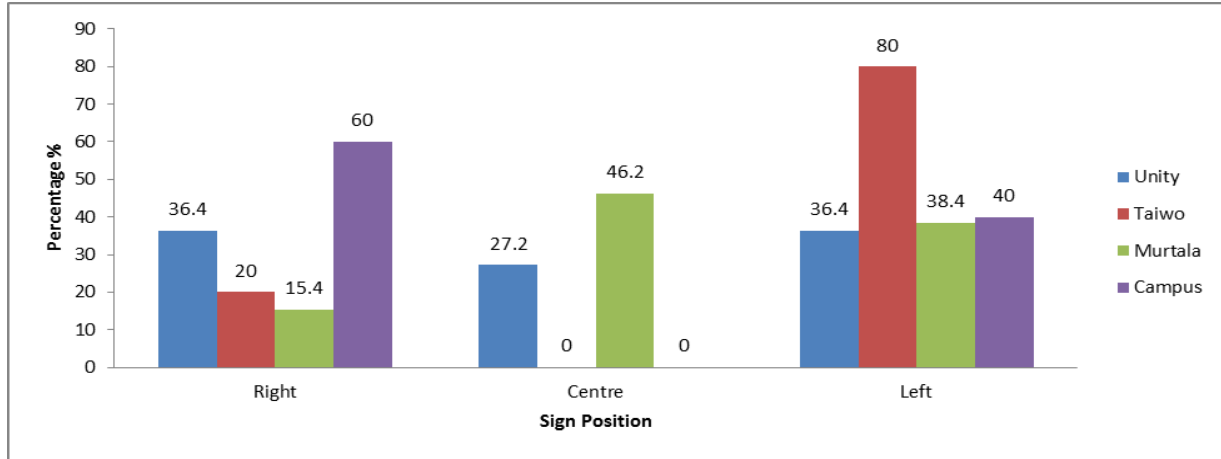


Figure 8 Comparison of the Sign Position

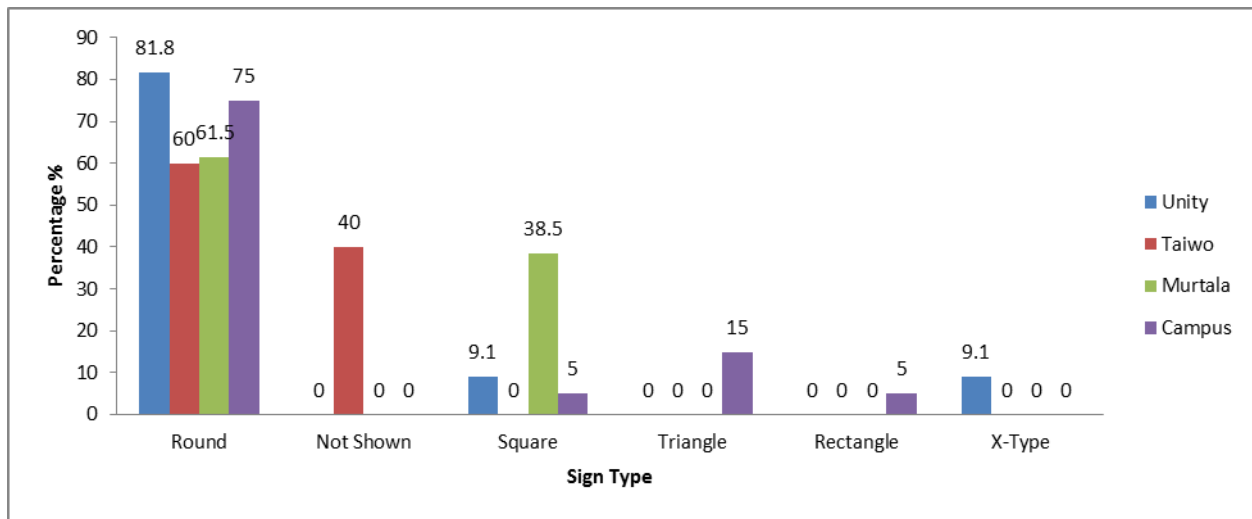


Figure 9 Comparison of the Sign Type

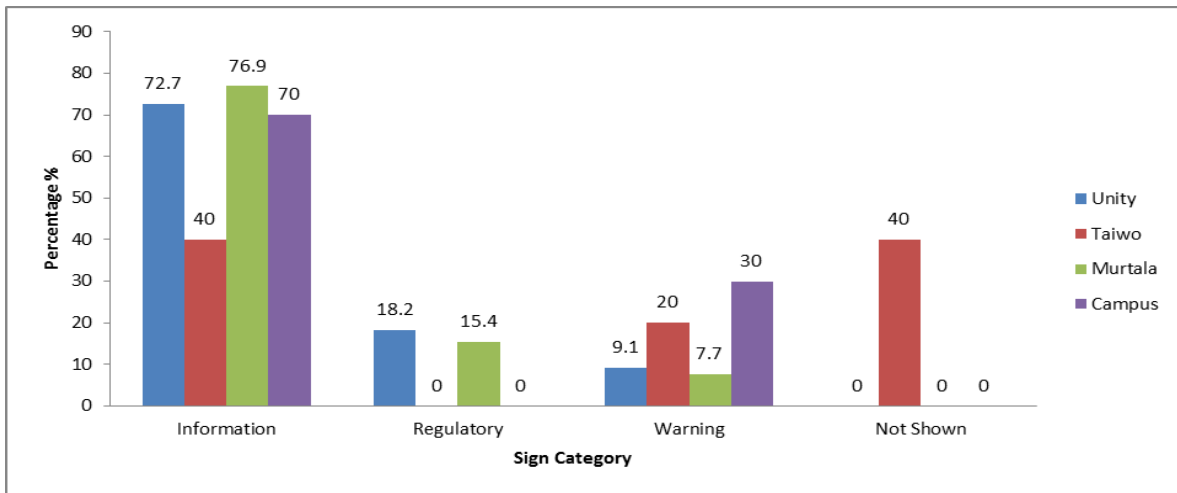


Figure 10 Comparison of the Sign Category

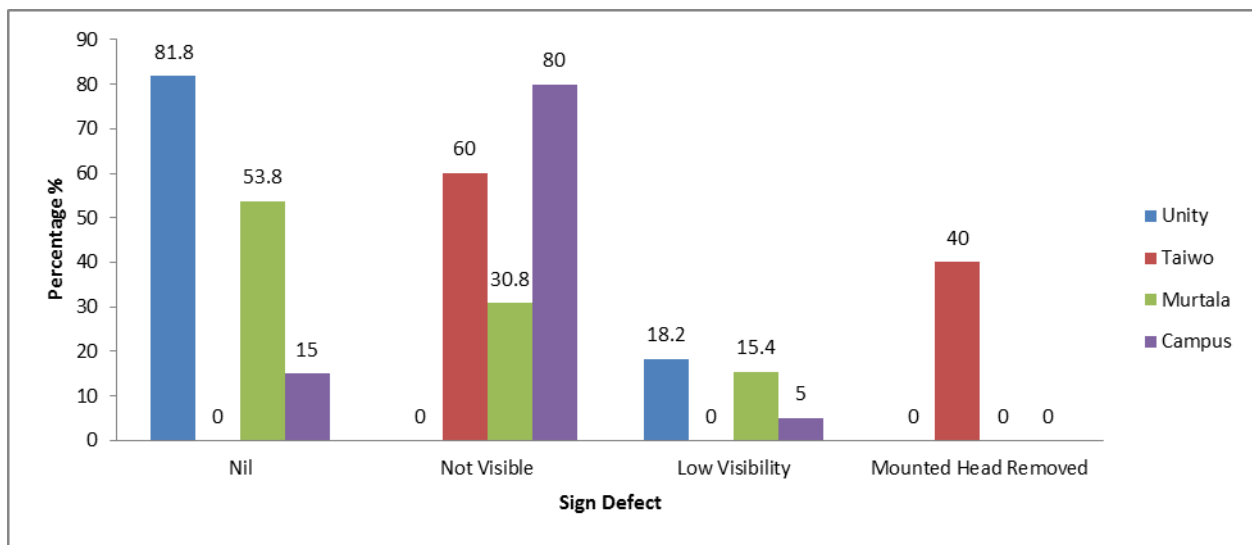


Figure 11 Comparison of the Sign Defect

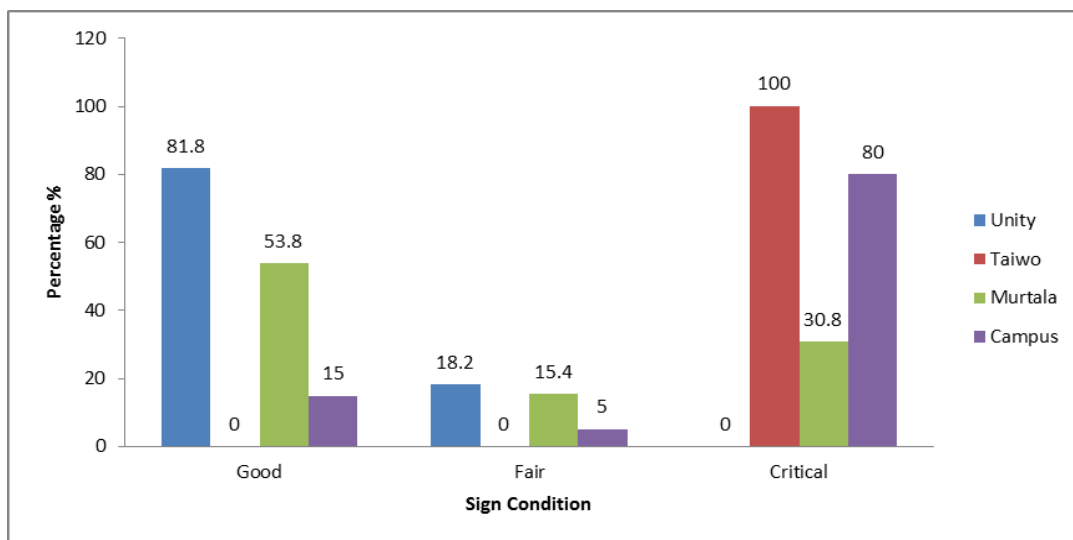


Figure 12 Comparison of the Sign Condition

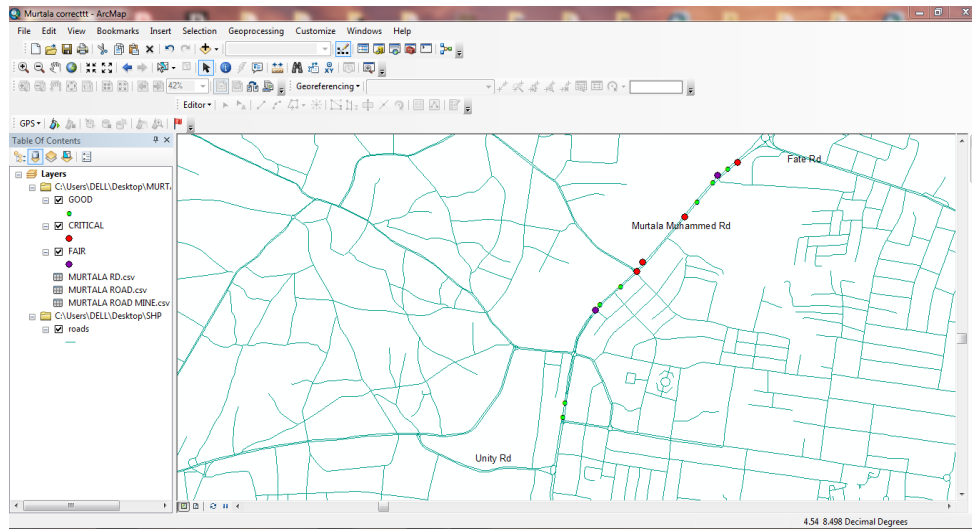


Figure 13 Traffic Signs Location at Murtala Mohammed Road

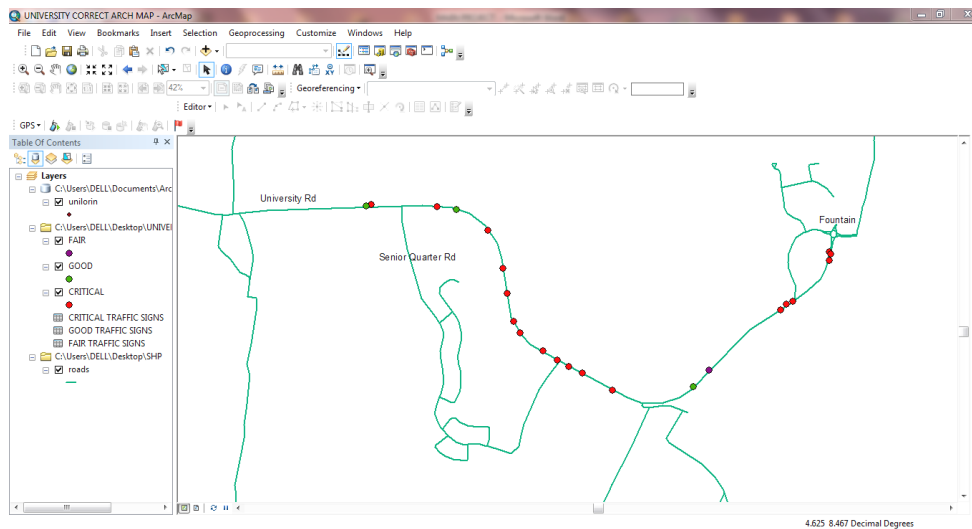


Figure 14 Traffic Signs Location at University of Ilorin Main Campus Road

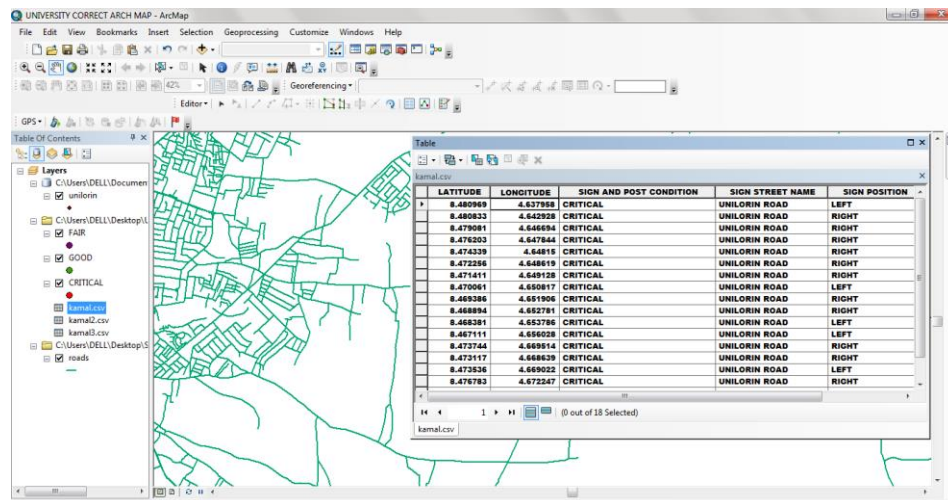


Figure 15 Attribute of collected data for Critical Traffic Signs at University of Ilorin Road

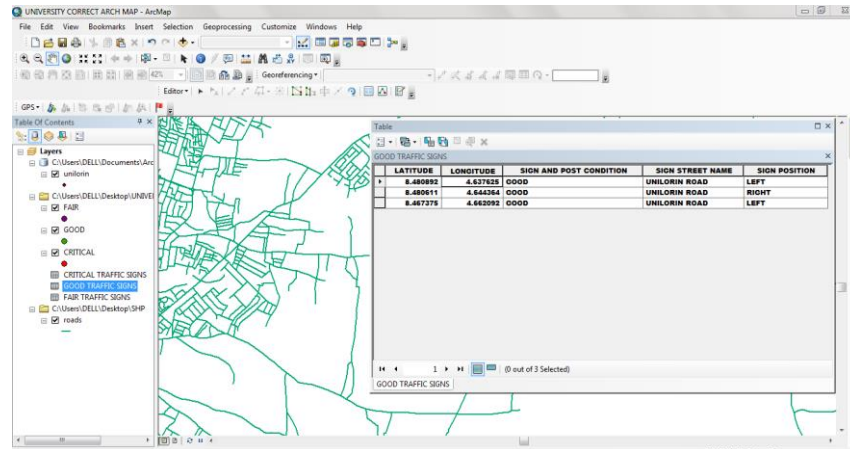


Figure 16 Attribute of collected data for Good Traffic Signs at University of Ilorin Road

Spatial search was used to query road traffic signs based on their location and / or attributes from the database. The process used to carry out the query operation involved opening of the attribute table on the layer menu. Then clicking on “select by attributes” on the table menu. In doing this, it is easy to query the database to display the critical, good and the fair traffic signs, their locations, the sign materials and other

information, for easy access to the traffic management/maintenance personnel. Figure 17 for example displays the outcome of the search ‘SIGN_POST CONDITION=GOOD AND SIGN_POSITION=CENTRE’ for Unity Road while Figure 18 is the outcome of the search ‘SIGN_POST CONDITION=CRITICAL’ for University of Ilorin Main Campus Road.

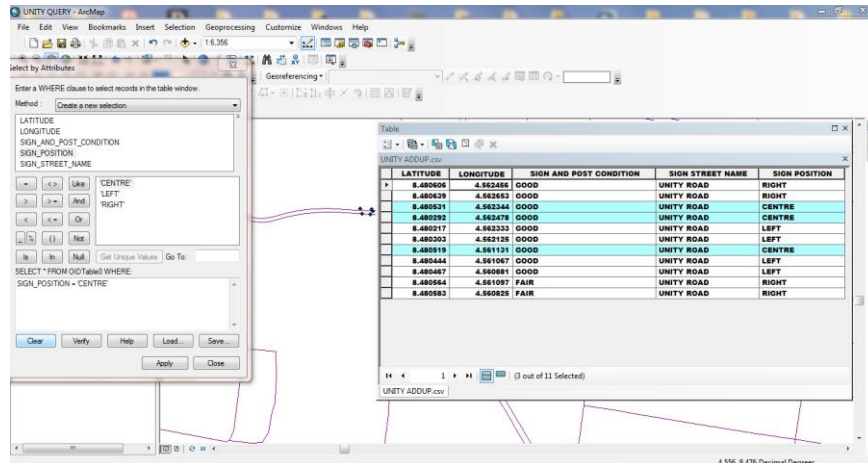


Figure 17 Result of query by Attributes showing all the good traffic signs at Unity Road

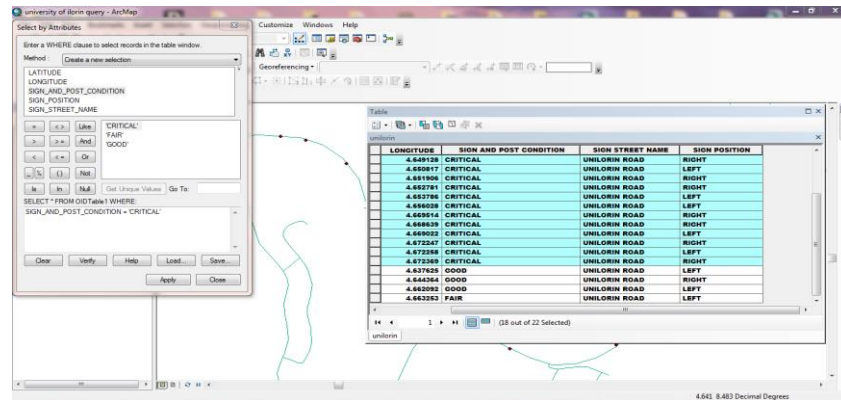


Figure 18 Result of query by Attributes showing all the critical signs on University of Ilorin Main Campus Road

4.0 CONCLUSION

4.1 Conclusion

The study designed and developed a GPS-GIS-based traffic sign asset management system. The study identified the critical, good and the fair traffic road signs along the Unity road, University of Ilorin Main Campus road, Murtala Mohammed road and Ibrahim Taiwo road in Ilorin Metropolis, Nigeria. The study showed that Unity road has nine good traffic signs and two fair traffic signs. At Ibrahim Taiwo road, the total number of traffic signs available is five and all are rated as critical traffic signs. At Murtala Mohammed road the total number of critical traffic signs is four, the good traffic signs is seven while the fair traffic signs is two. At University of Ilorin road, the number of critical traffic signs is sixteen and the number of good traffic signs is three while the number of fair traffic signs is one. The ArcGIS management system successfully captured the geographic locations of all the traffic signs and their attributes thereby enhancing visual display of the results of database queries on the condition of the traffic signs on each of the studied arterial. The study further identified locations where traffic signs should be placed but are lacking. The designed and developed database can be easily updated.

4.2 Recommendation

It is recommended that traffic road sign management agencies should adopt the use of the developed GPS-GIS based Traffic Sign Asset Management System for the management of traffic signs, pavement markings and road safety assets rather than manual method. Future study will explore the utilization of the advantages inherent in Laser Scanner technology for the development of a Laser Scanner- GIS- based road signage management system. In the proposed study the scans of the signages and asset data will be combined in GIS to build the system.

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