CARD International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 2, Number 3, September 2017
http://www.casirmediapublishing.com

Mapping of Road Pavement Failure along Eyenkorin–Ogbomoso Road using Geographical Information System (GIS) Approach

[1]O. M Olaniyan, [2]O. S. Olaniyan,, [3]M. B. Adediran,[4] Adebimpe Esan , [5]Adio-Yusuf
[2, 3, 5]Department of Civil Engineering, Ladoke Akintola University of Technology, Ogbomoso
[1, 4] Department of Computer Engineering, Federal University, Oye-Ekiti
Email: olatayo.olaniyan@fuoye.edu.ng
Corresponding Author: O. M. Olaniyan

ABSTRACT
Road transportation is one of the most promising and potent means for rapid industrialization and agricultural advancement. It plays an important role in economy of the country. This study accesses the pavement failure along Eyenkorin-Ogbomoso road using GIS approach. Coordinates of all failed portion along the alignment were located and describe while land use elevation map and road failure map were produced across the stretch were obtained with the use of Global Positioning System (Garmin 76GPS receiver) in UTM coordinate system. The dimensions of individual pavement failure was measured and recorded against their respective location coordinates, the imagery of the road was captured using Google Earth software. The imagery was geo-referenced and the failure coordinates plotted over the rectified imagery and the geo-database was evolved in ARCGIS 9.2 and the failure dimensions entered into the database. The length of the road is 47.6Km of single carriageway stretch between Eyenkorin – Ogbomoso transversing about fifteen communities. The pavement structure is made of 7.3m wide asphaltic concrete carriageway and 2.75m surface dressed shoulder on either side. The road has undergone series of palliative work since its existence. Presently, the road is in a very deplorable condition characterized by different failures such as cracks, peeling Edge, eroded shoulder, Potholes, Potholes, Rut, Raveling, and Washout etc. The outcome of this study reveals that adopting GIS to monitor road pavement failure is very advantageous for highways upgrading.
Keywords: Pavement Failure, GIS, GPS, Geo-Reference, Coordinates

INTRODUCTION

Transportation constitutes the main avenue through which different parts of the society are linked together. As a society grows in terms of population and functions, the need for interaction among its various components also grows

thereby requiring quality and effective transportation system. (Tom and Krishna, 2007). Advances in transportation has made possible changes in the way of living and the way in which societies are organised and therefore have a great influence in the development of civilizations. Road transportation is one of the most promising and potent means for rapid industrialization and agricultural advancement. For a road to be good it requires pavement which is the durable surface material laid down on an area intended to sustain vehicular traffic.

Road pavement is the durable surface material laid down on an area intended to sustain vehicular traffic. Pavements are designed to provide a reasonable smooth riding surface, adequate surface friction, to protect the subgrade and provide water proofing (Adlinge and Gupta, 2013). The major pavement types are rigid, flexible and composite pavement. A rigid pavement is basically a pavement design type consisting of a concrete slab resting on a well compacted granular base. The loads and stress are distributed over a wide area of subgrade by the rigidity and strength of the pavement. Flexible pavements consists several layers of natural granular material covered with one or more waterproof bituminous surface layers, and as the name imply, is considered to be flexible. A flexible pavement will bend under a load of tyre. The objective with the design of a flexible pavement is to avoid the excessive flexing of any layer, failure to achieve this will result in the over stressing of a layer, which ultimately will cause the pavement to fail (Adlinge and Gupta, 2013). Pavement failure is defined in terms of decreasing serviceability caused by the development of surface distresses such as cracks, potholes and ruts. They reported that before going into the maintenance strategies. It has been seen that only three parameters i.e. unevenness index, pavement cracking and rutting are considered while other distresses have been omitted while going for maintenance operations.

Literature Review

In Nigeria, there is challenge of road pavement failure hence many roads sited around had failed. However, the scene is the same along Eyenkorin-Ogbomoso road. A flexible pavement which is being considered in this study is made up of wearing course, binder course,

base course, sub base course and subgrade. Defects such as potholes, cracks, ravelling, washouts etc. plague road users, causing vehicle accidents, vehicles' damage and loss of lives and properties. Ogbomoso-Eyenkorin road is characterized with most of these failures. The extent and types of these failures were not available for the road users.

Furthermore, functional failure is a broader term, which may indicate the loss of any function of the pavement such as skid resistance, structural capacity, and serviceability or passenger comfort. Materials failure occurs due to the disintegration or loss of material characteristics of any of the component materials. Caltrans categorized the main types of pavement failures as either deformation failures or surface texture failures. Deformation failures include corrugations, depressions, potholes, rutting and shoving. These failures may be due to either traffic (load associated) or environmental (non load associated) influences. It may also reflect serious underlying structural or material problems that may lead to cracking. Surface texture failures include bleeding, cracking, polishing, stripping and ravelling. These failures indicate that while the road pavement may still be structurally sound, the surface no longer performs the function it is designed to do, which is normally to provide skid resistance, a smooth running surface and water tightness. Other miscellaneous types of pavement failures include edge defects, patching and roughness (Magdi and Zumrawi, 2013).

Cracks can occur in a wide variety of patterns. They may result from a large number of causes, but generally are the result of either ageing and embrittlement of surfacing, environmental conditions, structural or fatigue failure of the pavement, or any other causes. The formation of cracks in the pavement surface causes numerous problems such as discomfort to the users, reduction of safety, etc. In addition to the above, intrusion of water causing reduction of the strength in lower layers as well as lowering of bearing capacity of subgrade soil by pumping of soil particles through the cracks is also a major problem associated with the pavements. This leads to the progressive degradation of the road pavement structure in the neighbourhood of the cracks. The

origin of cracks differs by their shapes, configuration, amplitude of loading, movement of traffic and rate of deformation (Magdi and Zumrawi, 2013). These present work will access the pavement failure along Eyenkorin-Ogbomoso using Geographic Information System(GIS) approach so as to reduce accident and travel time and definitely safe cost and assist in decision making while road users ply the road. The system is designed to capture, store, manipulate, analyse, manage, and present all types of spatial or geographical data. The acronym GIS is sometimes used for geographic information science which refers to the academic discipline that studies geographic information systems and is a large domain within the broader academic discipline of Geoinformatics. GIS applications are tools that allow users to create interactive queries (user-created searches), analyse spatial information, edit data in maps, and present the results of all these operations.

METHODOLOGY

The study was carried out along Eyenkorin–Ogbomoso road which is a Federal road. It is part of the Lagos-Kano Trans sahara R20 (A1) road network that links the southern part of Nigeria to the northern part. It was constructed in the year 1973 by the Federal Ministry of Works. The traffic on the road is heavy in volume and substantial parts of the traffic are heavy loaded trucks due to the import and export of goods through Lagos port. The length of the road is 47.6Km of single carriageway stretch between Eyenkorin–Ogbomoso transversing about fifteen communities. The pavement structure is made of 7.3m wide asphaltic concrete carriageway and 2.75m surface dressed shoulder on either side. The road has undergone series of palliative work since its existence. Presently, the road is in a very deplorable condition characterised by different failure such as, potholes, cracks, rutting, peeling and others (Source: Federal Ministry of Works). The study area is shown in figure 1.

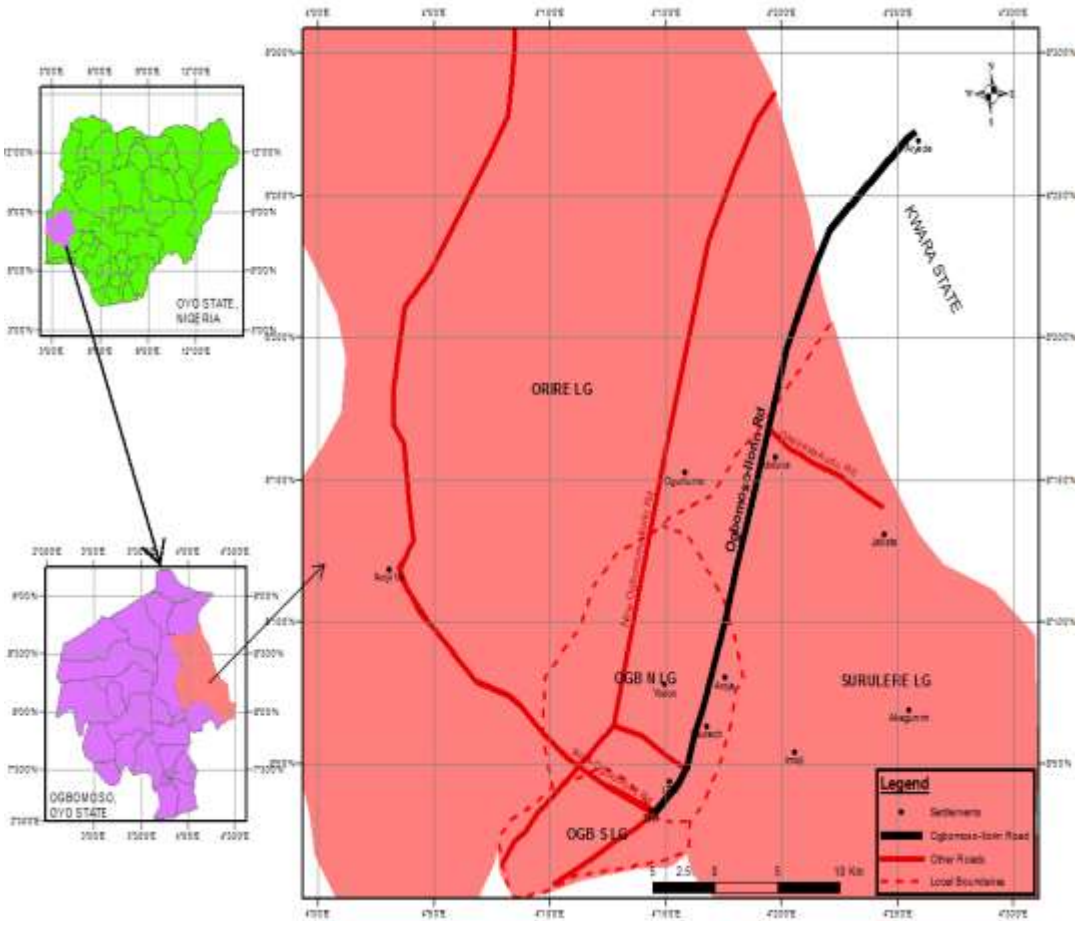

Figure 3.1: Shows the Map of Eyenkorin-Ogbomoso Road
Source: ESRI ArcGIS, 2010 Version

Site investigation was performed by a team of eight people consisting of authors, surveyor and other supporting workforce. The method of investigation involved making a physical trip along the entire stretch of the road, identified every observable failure along the road. The positional coordinates of pavement failure locations were obtained with the use of Global Positioning System (Garmin 76 GPS receiver) in UTM coordinate system. The dimensions of individual pavement failure were measured and recorded against their respective location coordinates. In addition, the imagery of the road was captured using Google Earth software. The imagery was geo-referenced and the failure location coordinated plotted over the

rectified imagery. Having captured the required data, a geo-database was designed based on the view of reality, conceptual framework, logical design and physical model in Arc GIS 9.2 of 2010 and the failure dimensions entered into the database. The software (Arcgis) was then used to analyze the failure location dimensions to generate the road pavement failure map showing variation in the types of failure as well as variation in the dimensions of the respective pavement failures.

RESULTS AND DISCUSSION

The outcome of this work revealed seven categories of pavement failure on Eyenkorin-Ogbomoso road which are Edge Crack/Eroded shoulder, Potholes, Cracks, Potholes, Rut, Ravelling, and Washout. Precluding the actual discussion of results, it is important to put in the perspective of the types, nature and size of pavement failure with respective locations. Edge-Break failure was noticed at different location along the road which are Eyenkorin community, Afon – Ogele junction, Balla junction, Otte and Gbede. The types, nature and size of pavement failure with respective locations of Edge-Break failure are shown in Table 4.1. Fatigue cracks and potholes failure are seen at two different locations along the road. The former was observed at lafoju and olofe with the highest volume of failure existing at olofe with value of 130.31m^3 and coordinates of longitude and latitude 4.362097 and 8.385748 respectively while the latter was observed at Eyenkorin community and Idi-Ami with maximum failure volume existing with a value of 2.78m^3 at Eyenkorin community with coordinates of longitude and latitude 4.415022 and 8.460961 respectively and the least failure volume existed at Idi-Ami. The discussion of fatigue cracks and potholes are hallmark of Table 4.2 and 4.3. Cracks with potholes both existed at three different locations which are Eyenkorin Community, Abduka and Egbeda via Ogbomoso with the highest failure volume of 68.3m^3 at Egbeda via ogbomoso, coordinates of longitude 4.29995 and latitude 8.196733 as shown in Table 4.4. Rut existed at two different locations with are Adabata and Ojutaye with the latter having highest failure volume of 160.65m^3 while raveling occurred at one location only which is along Sabo Araromi-Odo Oba with failure volume of 327.04m^3 as shown in Table 4.5 and 4.6. Wash out failure was seen in seven locations at otte

road with the highest failure volume with 312m^3, coordinates of longitude 4.351947 and latitude 8.36412 while least volume has 2.52m^3 value of failure volume with coordinates of longitude 4.345424 and latitude 8.348663 as shown in Table 4.7. Map failure on Eyenkorin-Ogbomoso road and elevation map of Eyekorin-Ogbomoso road are shown in Figure 2 and Figure 3 respectively.

Table 4.1: Types, Nature and Size of Pavement Failure with Locations (Edge-Break)

S/N	Types of Failure	Description	Location	Length (m)	Width (m)	Depth (m)	Area (m^2)	Volume (m^3)	Coordinates
1	Edge Crack/ Eroded Shoulder	The entire bituminous surface has been washed away as a result of non-functionality of the drain	Eyenkorin community	47,559 (The entire stretch).	5.5 (Both sides)	0.5 (Average for entire stretch)	261,575	130,787	**Longitude:** 4.419755 **Latitude:** 8.463787
2	Edge Crack/ Eroded Shoulder	Eroded shoulder. The entire bituminous surface has been washed away as a result of no drain/access culvert	Afon – Ogele junction	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	**Longitude:** 4.400706 **Latitude:** 8.447717
3	Edge Crack/ Eroded Shoulder	Eroded shoulder. The entire bituminous surface has been washed away as a result of no drain/access culvert	Balla junction	as been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	**Longitude:** 4.392611 **Latitude:** 8.435678

S/No	TYPES OF FAILURE	DESCRIPTION	LOCATION	LENGTH (m)	WIDTH (m)	DEPTH (m)	AREA (m^2)	VOLUME (m^3)	COORDINATES

4	Edge Crack/ Eroded Shoulder	Eroded shoulder. The entire bituminous surface has been washed away as a result of no drain/access culvert	Otte	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	**Longitude:** 4.355649 **Latitude:** 8.372638
5	Edge Crack/ Eroded Shoulder	Eroded shoulder. The entire bituminous surface has been washed away as a result of no drain/access culvert	Gbede	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	Has been captured from item No 1	**Longitude:** 4.331894 **Latitude:** 8.311346

Table 4.2: Types, Nature and Size of Pavement Failure with Locations (Potholes)

S/No	TYPES OF FAILURE	DESCRIPTION	LOCATION	LENGTH (m)	WIDTH (m)	DEPTH (m)	AREA (m^2)	VOLUME (m^3)	COORDINATES
1	Potholes	Ditches on carriageway exposing the base course of the road	Eyenkorin community	2.02	4.25	0.3	8.59	2.58	**Longitude:** 4.415022 **Latitude:** 8.460961
2	Potholes	Ditches on carriageway exposing the base course of the road	Idi-Emi	0.5	0.7	0.3	0.35	0.11	**Longitude:** 4.38357 **Latitude:** 8.423489

Table 4.3: Types, Nature and Size of Pavement Failure with Locations (Fatigue Cracks)

S/N	TYPES OF FAILURE	DESCRIPTION	LOCATION	LENGTH (m)	WIDTH (m)	DEPTH (m)	AREA (m^2)	VOLUME (m^3)	COORDINATES
1	Cracks (Fatigue)	Web cracks. A combination of longitudinal and transverse crack on the carriageway of the road	Lasoju	53	1.78	0.3	94.34	28.3	**Longitude:** 4.371595 **Latitude:** 8.406392
2	Cracks (Fatigue)	Web cracks. A combination of longitudinal and transverse crack on the carriageway of the road	Olofe	59.5	7.3	0.3	434.35	130.31	**Longitude:** 4.362097 **Latitude:** 8.385748

Table 4.4: Types, Nature and Size of Pavement Failure Locations (Cracks and Potholes)

S/No	TYPES OF FAILURE	DESCRIPTION	LOCATION	LENGTH (m)	WIDTH (m)	DEPTH (m)	AREA (m^2)	VOLUME (m^3)	COORDINATES
1	Cracks and Potholes	Cracks with different size of ditches on carriageway	Eyenkorin community	156	0.68	0.3	106,08	31.82	**Longitude:** 4.41099 **Latitude:** 8.458354
2	Cracks and Potholes	Cracks with different size of ditches on carriageway	Abduka	112	0.78	0.3	87.36	26.21	**Longitude:** 4.324368 **Latitude:** 8.282343
3	Cracks and Potholes	Cracks with different size of ditches on carriageway	Egbeda via Ogbomoso	83.7	2.72	0.3	227.66	68.3	**Longitude:** 4.29995 **Latitude:** 8.196737
S/No	TYPES OF FAILURE	DESCRIPTION	LOCATION	LENGTH (m)	WIDTH (m)	DEPTH (m)	AREA (m^2)	VOLUME (m^3)	COORDINATES
5	Washout	Complete failure of all road profile	Otte	5.65	4.25	0.57	24.01	13.69	**Longitude:** 4.347329 **Latitude:** 8.35305
6	Washout	Complete failure of all road profile	Otte	1.12	5	0.45	5.6	2.52	**Longitude:** 4.345424 **Latitude:**

									8.348663
7	Washout	Complete failure of all road profile	Otte	13.1	3.5	1.25	45.8	57.31	**Longitude:** 4.344081 **Latitude:** 8.345031

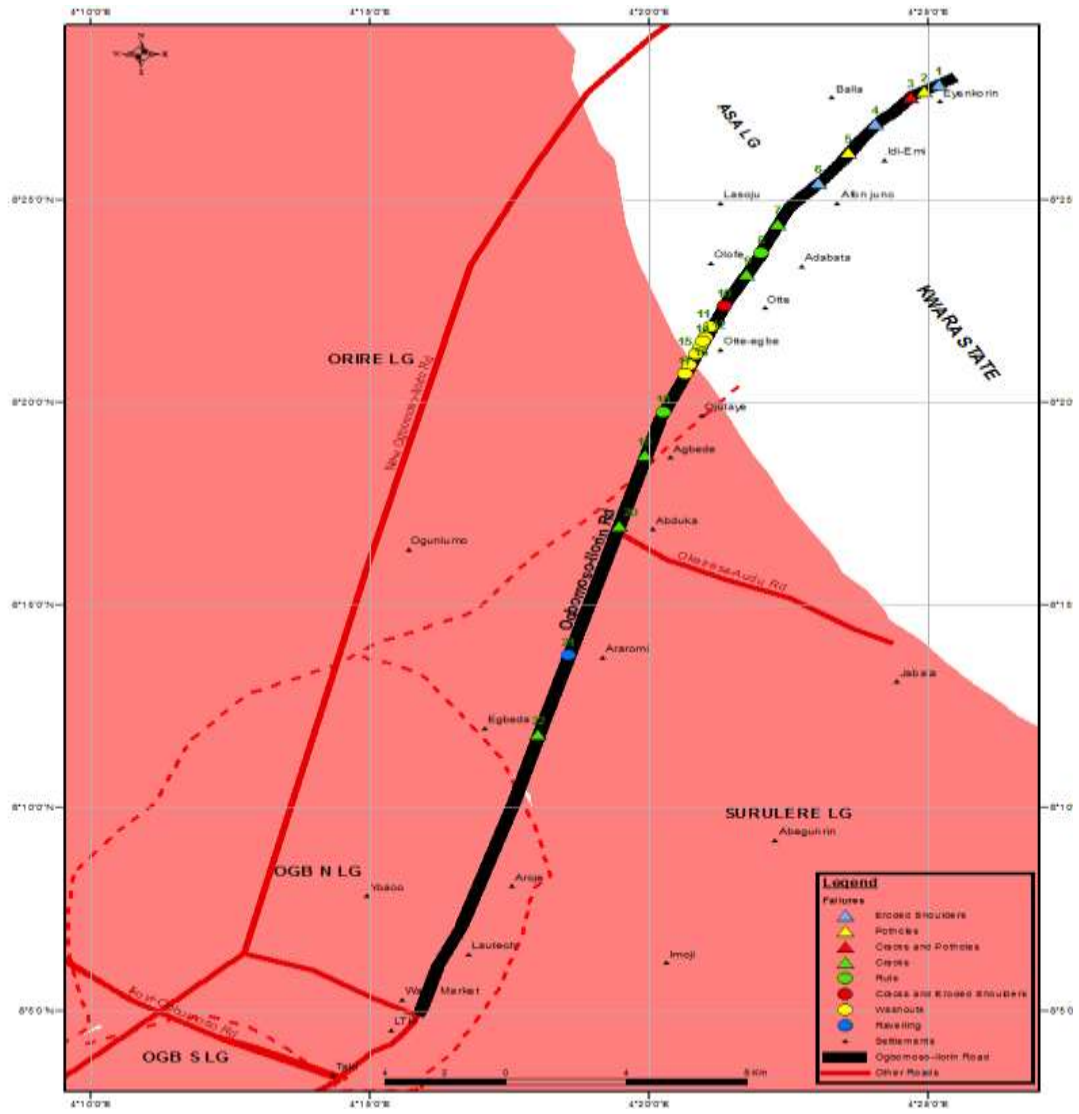

Figure 2: Shows the Failure on Eyenkorin-Ogbomoso Road
Source: ESRI ArcGIS, 2010 Version

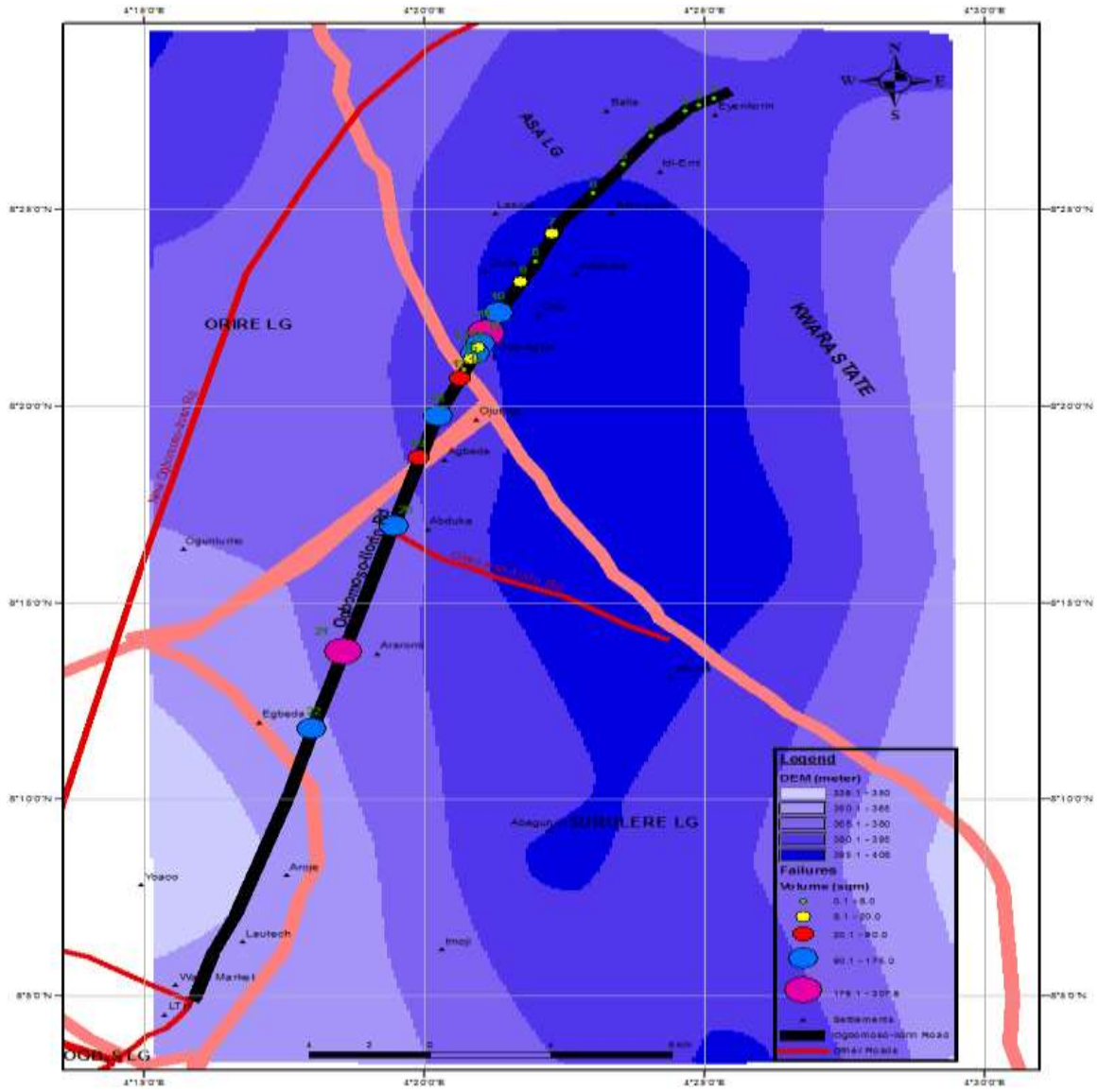

Figure 3: Elevation Map of Eyekorin-Ogbomoso Road in Meter
Source: ESRI ArcGIS, 2010 Version

CONCLUSION AND RECOMMENDATIONS

The outcome of this study reveals that adopting GIS to monitor road pavement failure is very advantageous for highways upgrading.

It is therefore recommended that all our highways should be periodically monitored with GIS application to identify the extent of

pavement failure and immediate preventive measures to be adopted.

REFERENCES

Adlinge, S.S. and Gupta, A.K., (2013). *Pavement Deterioration and its Causes Journal of Mechanical & Civil Engineering: J.J. Magdum College of Engineering, Shivaji University, India. pp 09 – 15.*

Ajibade, G.O., (2012). *Geographic Information System (GIS) Based Road Inventory in Kwara State: A Project Report submitted to the Department of Civil Engineering, University of Ilorin, Nigeria.*

Azebeokhai, J.D. (2015). *Study of Pavement Deterioration on Adewole/University Road, Ilorin, Kwara State: A Project Report submitted to the Department of Civil Engineering, University of Ilorin, Nigeria.*

Dienye, A. and Emmanuel A. (2014). *A GIS Based Road Network System of Port Harcourt, Nigeria: FIG Congress 2014 Engaging the Challenges – Enhancing the RelevanceKuala Lumpur, Malaysia 16-21 June 2014.*

Flexible Pavement Design Manual (2015). *Office of Design, Pavement Management Section, Tallahassee, Florida.* GIS on Highways, (www.esri.com/industries/highways). GIS Tutorials, (www.esri.com/transportation).

Magdi and Zumrani, (2013). *Survey and Evaluation of Flexible Pavement Failure: An International Journal of Science and Research.*

Ndefor O., (2012) *Causes of Highway Failures in Nigeria: International Journal of Engineering and Technology (IJEST).*

Pavement Design Guide.doc/HMRB CD version 2/October 2001/page 26 of 54.

Pavement Design Manual (2002). *Department of Transportation Highways Division, Materials Testing and Research Branch Soils Engineering and Pavement Design Section, Honolulu Highway.*

Mr Pothole (2009). *Pavement Restoration Specialist Industry.*

Tom V.M. and Krishna K.V. (2007). *Introduction to Transportation Engineering to National*

Programme on Technology Enhanced Learning (NPTEL).

Yancey, Molner (2011). *GIS Applications and Integration on Transportation Planning and Design Project.*