Road Infrastructure Strategic Framework: A Panacea for Effective Transportation System in Nigeria

BY

ENGR. O. S. V. ODUWOLE, FNSE, FCAI, Engr. Ben Ekwueme, FNSE & ***Engr. Lanre Aiyegoro, MNSE,**
***Deputy Director of Entrepreneurship, Federal Polytechnic, Nekede, Owerri**
****Former Commissioner for Public Utilities, Imo State**
*****Principal Partner, Lans Consult, Lagos**

N.B: * Engr. O. S. V. Oduwole is the corresponding author. All enquiries should be directed to him

ABSTRACT
This paper makes it clear that the basic network information with which an efficient decision support system can be maintained is lacking from our road agencies. The need to rectify this unhealthy situation motivates the extended conclusions and recommendations given in the paper.
A Road Maintenance System (RMS) incorporating various disaster-prevention measures which makes it possible for all road maintenance officers to grasp real-time, the traffic regulations and detours to avoid them all over the prefecture is proposed.
A model, "Family of Measures" designed to represent the performance of transportation systems from three different perspectives, including government, road administrators and road users, developed by the Europe-based Organization for Economic Cooperation and Development (OECD) is proposed for use in Nigeria, if the benefits of our road transportation will be maximized.

1.0 INTRODUCTION:

1.1 ROAD CONSTRUCTION

Road construction requires the creation of a continuous right-of-way, overcoming geographic obstacles and having grades low enough to permit vehicle or foot travel and may be required to meet standards set by law or official guidelines (O'Flaherty, 2002). The process is often begun with the removal of earth and rock by digging or blasting, construction of embankments, bridges and tunnels, and removal of vegetation (this may involve deforestation) and followed by the laying of pavement material. A variety of road building equipment is employed in road building.

After design, approval, planning, legal and environmental considerations have been addressed alignment of the road is set out by a surveyor. The radii and gradient are designed and staked out to best suit the natural ground levels and minimize the amount of cut and fill (Kincaid, 1986). Great care is taken to preserve reference benchmarks
Roadways are designed and built for primary use by vehicular and pedestrian traffic (Lay,1992). Storm drainage and environmental considerations are a major concern. Erosion and sediment controls are constructed to prevent detrimental effects. Drainage lines are laid with sealed joints in the road easement with runoff coefficients and characteristics adequate for the land zoning and storm water system. Drainage systems must be capable of carrying the ultimate design flow from the upstream catchment with approval for the outfall from the appropriate agency to a watercourse, creek, river or the sea for drainage discharge.
General fill material should be free of organics (Oduwole,2002), meet minimum California bearing ratio (CBR) results and have a low plasticity index. Select fill (sieved) should be composed of gravel, decomposed rock or broken rock below a specified particle size and be free of large lumps of clay. Sandy clay fill may also be used. The road bed must be "proof rolled" after each layer of fill is compacted. If a roller passes over an area without creating visible deformation or spring, the section is deemed to comply.
The completed road way is finished by paving or left with a gravel or other natural surface. The type of road surface is dependent on economic factors and expected usage. Safety improvements like traffic signs, crash barriers, raised pavement

markers, and other forms of road surface marking are installed.

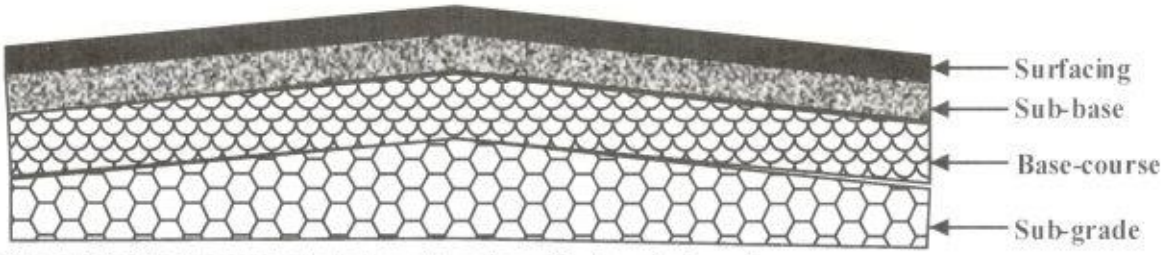

Fig. 1: Typical pavement stratum for a heavily traveled road

1.2 Road Deterioration And Maintenance

Like all structures, roads deteriorate over time. Deterioration is primarily due to accumulated damage from vehicles (Oduwole and Aiyegoro, 2008a-d). However, environmental effects such as frost heaves, thermal cracking and oxidation often contribute. According to a series of experiments carried out in the late 1950s, called the AASHO Road Test, it was empirically determined that the effective damage done to the road is roughly proportional to the 4th power of axle weight. A typical tractor-trailer weighing 80,000 pounds (36.287 tonnes) with 8,000 pounds (3.6287 tonnes) on the steer axle and 36,000 pounds (16.329 tonnes) on both of the tandem axle groups is expected to do 7,800 times more damage than a passenger vehicle with 2,000 pounds (0.907 tonnes) on each axle. Potholes on roads are caused by small cracks, which when left untreated, grow into bigger cracks which eventually get dislodged by traffic action or rain damage and vehicle braking or related construction works (Oduwole and Aiyegoro, 2008c).

Pavements are designed for an expected service life or design life. Maintenance is considered in the whole life cost of the road with service at 10, 20 and 30 year milestones (Oduwole and Aiyegoro, 2008g). Roads can be and are designed for a variety of lives (8-, 15-, 30-, and 60-year designs). When pavement lasts longer than its intended life, it may have been overbuilt, and the original costs may have been too high. When a pavement fails before its intended design life, the owner may have excessive repair and rehabilitation costs (Nwariaku, 2009). Many concrete pavements built since the 1950s have significantly outlived their intended design lives. Some roads like Chicago, Illinois's "Wacker Drive", a major two-level viaduct in downtown area are being rebuilt with a designed service life of 100 years.

Virtually all roads require some form of maintenance before they come to the end of their service life. Pro-active agencies continually monitor road conditions and apply preventive maintenance treatments as needed to prolong the lifespan of their roads. Technically advanced agencies monitor the road network surface condition with sophisticated equipment such as laser/inertial profile meters. These measurements include road curvature, cross slope, unevenness, roughness, rutting and texture (roads). These data are fed into a pavement management system, which recommends the best maintenance or construction treatment to correct the damage that has occurred.

Maintenance treatments for asphalt concrete generally include crack sealing, surface rejuvenating, fog sealing, micro-milling and surface treatments. Thin surfacing preserves, protects and improves the functional condition of the road while reducing the need for routine maintenance, leading to extended service life without increasing structural capacity.

2.0 Overview of current situation regarding management systems

The overview presented in this section is based on extensive discussions and interactions held with road agencies over a period of time, as well as on discussions with consultants and other experts in the field. A comprehensive, scientific audit of Road Asset Management Systems (RAMSs) currently used in Nigeria would still need to be conducted (Oduwole and Aiyegoro, 2008g).

2.1 Overview of intra-agency systems

By intra-agency system, we mean, those systems for road maintenance within road construction and maintenance agencies of the government at the

three levels (federal, state and local) of government. For each level of government, the following should be indicated:

- Whether there are systems in place, how good they are, problems encountered, examples of good systems (where applicable);
- How systems for "peer" agencies (agencies in the same level of government) compare, and
- How systems between different levels of government compare (i.e. national, state and municipal spheres).

Table 1: Current situation regarding intra-agency systems in different spheres of government.

Sphere of government		Description
1	Federal Roads Maintenance Agency (FERMA)	Demonstrably the most fully integrated system of all the road agencies. Used for cross-linked managerial decision support on all activity levels. Ready for inter-agency linking. Systematic user-need programming. Yet, still being refined. Easy to obtain any network and budget information. Consultants are utilized to assist and alleviate specialist shortage.
2	States Road Maintenance Agencies	Variable availability of network information. A few of the states have well developed Management Information System (MIS) and Decision Support System (DSS), although not fully integrated yet, especially at budgeting level. About one third of the states have only barest essentials of a non-integrated MIS in place. The others are well on their way to having their MIS in place, albeit none of them is presently utilizing consultants to assist them and alleviate specialist shortage.
3	Local Government Areas Road Maintenance Agencies	Variable availability of, basically non-integrated, network information. Local Government Supervisory Councilors for Works presently handle road maintenance at the Local Government levels. Most of these roads are earth roads.

Table 1 reveals the wide spread regarding progress made in implementing management systems in the different levels of government. At national roads level, for example, key systems are already in place, whereas almost all the Local Government Areas have no systems at all. The general pattern that emerges is that the situation deteriorates as one moves from the top to the bottom of Table 1. Table 1 therefore highlights areas to which attention and resources for setting up information systems should be focused.

2.2 Overview of inter-agency system

At present, there is no custom-made inter-agency (i.e. interaction between/among the three levels of Government) system specifically set up for managing the road network at a strategy level. The annual "Transport Statistics" document does go some distance in providing such information (Oduwole and Aiyegoro, 2006b&2008d). However, it was never intended as an intra-agency management system. Also, it does not provide any information and/or key performance indicators for the Local Goverment level of government. It is suspected that this is due to the fact that systems are not always in place for this sphere of government and, consequently, such information is not available. This highlights the need for inter-agency systems to be put in place such that the following management systems will be carried out within the agency: road register, structure, traffic safety facilities, road property, disaster prevention information, occupied object, road traffic cencus, road network analysis, road surface properties data and statistical accident data management. Once this is done, these systems can source a "purpose-made" intra-agency system that, in its turn, will facilitate the preparation of the "summary" documents such as the annual Transport Statistics publication.

3.0 ROAD INFRASTRUCTURE STRATEGIC FRAMEWORK FOR NIGERIA

In developing a road infrastructure strategic framework for Nigeria, it is necessary to use management systems involving a number of

important concepts as defined and explained below with their linkages also illustrated in Figure 1.

3.1 Asset Monitoring: Asset Monitoring (AM) is defined as that process whereby the condition and behaviour of road assets are assessed and recorded on a regular basis. This may be done on a formal and/or informal basis, where "informal basis" refers to feedback from road users, which typically occurs on an ad hoc basis. These road assets typically are the responsibility and under control of the road agency. See bottom sphere in Figure 1, which typically illustrates the generic structure of an intra-agency management system.

3.2 Road Asset Management System: A Road Asset Management System (RAMS) is defined as a structured procedure, directed in a functionally integrated manner, to facilitate coordinated over-all management of a road agency aimed at ensuring the desired level of service delivery. A RAMS typically comprises the various (functional) Management Systems (MSs), such as the Construction Management System (CMS), Pavement Management System (PMS), Maintenance Management System (MMS), Bridge Management System (BMS), etc. See middle sphere in Figure 1.

3.3 Management Information System: A Management Information System (MIS) is defined as any systemized and structured procedure whereby information pertaining to a well-structured management problem is gathered, retained, manipulated and/or supplied, either manually or by computer, in terms of pre-defined filters, aggregation rules, objective functions and/or optimization algorithms. See middle sphere in Figure 1.

3.4 Decision Support System: A Decision Support System (DSS) is defined as a system aimed at addressing semi-structured or unstructured strategic decision-making problems, and therefore facilitates the explorative search adaptation and use of multiple models, perspectives, or problem-processing methods. See also top management sphere in Figure 1.

Note: Typically, DSSs make use of certain key performance indicators (KPIs) to aid decision-making at strategic level, delivery strategy and to track changes of the road networks over time. For road performance, typical KPIs include the International Roughness Index (IRI) and the Visual Condition Index (VCI). KPIs also include funding indices such as costs/km, backlog costs, future costs, indices on poverty alleviation in order to aid in mobility and accessibility, etc. They also include scenario planning to trace and project functional and structural services to the public. There is a need to develop more Nigeria -specific KPIs to assist in its current developmental state of road maintenance and provision both in the intra- and inter-agency management systems. See section 3.5 for more details.

3.5 Intra-agency and inter-agency systems: It is important to distinguish between intra-agency and inter-agency systems. An intra-agency system is defined as the system needed to enable a particular road agency to manage the road network effectively within its area of jurisdiction. The RAMS (as defined above) therefore is an intra-agency system. On the other hand, an inter-agency system is defined as a system needed for the coordination of activities between any selected group of road agencies, normally at a strategy level, in pursuing common goals and objectives. It consists of key information sourced from selected intra-agency systems and combined into a single inter-agency system. The data types contained therein would therefore be information needed for managing the road network for a specified region at a strategy level.

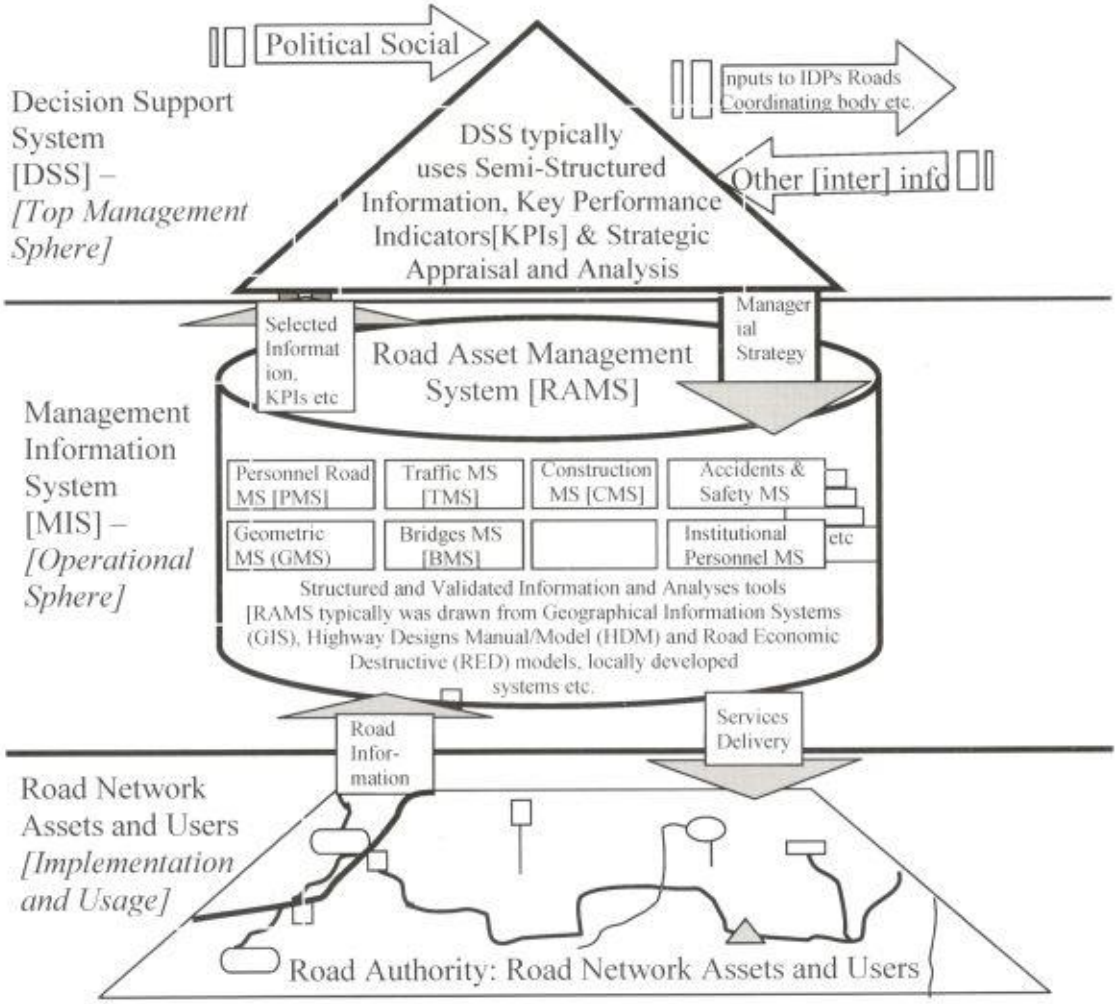

Figure 1: Generic Intra-Agency Road Management System.

(Source: Oduwole & Aiyegoro, 2008g)

4.0 Towards ideal management systems for Nigerian road networks

4.1 Intra-Agency Road Management System

The identified lack of intra-agency systems has been highlighted and it is suggested that urgent attention be given to setting up such systems (Oduwole and Aiyegoro, 2008b,d,e,f,g). As discussed previously, a generic intra-road management system is illustrated in Figure 2. The design of this figure is self-explanatory, but in essence, the road network (asset) data captured from the jurisdiction of the road agency is fed directly into the MIS with its various road asset management systems (RAMS) such as the PMS, BMS, GMS, AMS (including crash data base) etc. After validation, analyses and value addition the data enter the DSS at a strategic level. Inputs from political, social and other regional (spatial) information are analysed in the DSS sphere and are evaluated with the local information. The links to other road agencies (i.e. inter) are also shown in the figure.

4.2 Inter-Agency Road Management System

To facilitate inter-agency linkages on a nationwide scale, both vertically and laterally, selected information from each road agency's MIS and DSS

should ideally be captured centrally in a national "nationwide" information system. The linkages of such a national information system with all road agencies are generically illustrated in Figure 2.

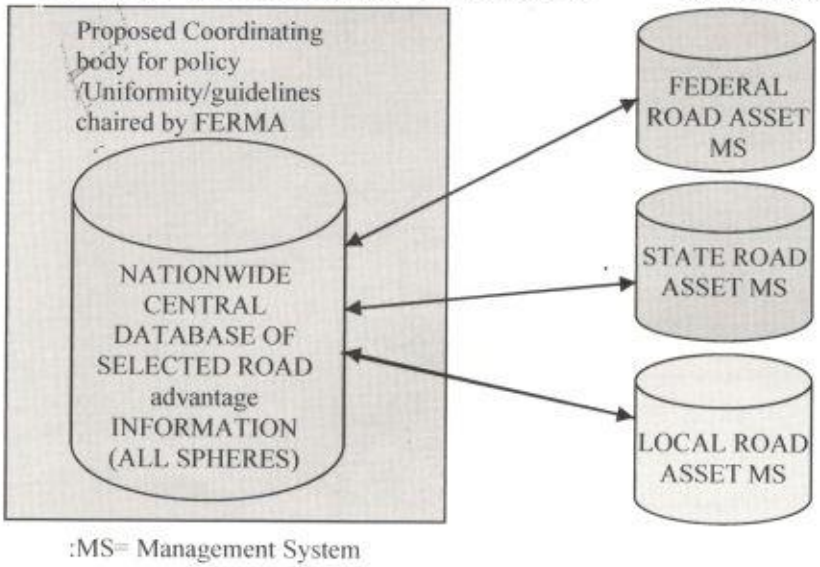

Figure 2: Proposed relationship between Federal, State and Local Government road management, and a central nationwide database of selected information under supervision of the Federal Road Maintenance Agency.

(Source: Oduwole and Aiyegoro, 2008g)

5.0 Conclusions and Recommendations

5.1 Conclusions

Importance of information and decision support systems

Information and decision support systems are indispensable for the effective management of the road network at both the operations and strategy levels, in order to ensure good governance outcomes and optimal service delivery. A generic intra-agency road (asset) management system is proposed in Figure 1 to serve as a guide.

Need to distinguish between intra- and inter-agency systems

Although both are important, it is necessary to distinguish between an intra-agency system and an inter-agency system. An intra-agency system aims to provide a given road agency with the information and decision support needed to manage the road network under its jurisdiction. An inter-agency system focuses on facilitating coordination between road networks and road agencies, usually at a strategy level, and aims to ensure alignment of functions such as planning, programming, execution and funding between these agencies. Linkages are proposed between national and regional road asset management systems towards the nationwide central database of selected information.

Need to focus on systems that are appropriate in the Nigerian context

Rather than introducing high-tech solutions, the emphasis should be on systems appropriate to the Nigerian context. In many instances, this amounts to "simple systems that work" and "doing the obvious". Information and decision support systems should also be integrated and developed. They should also be compatible with ICT (Information and Communication Technology) guidelines and requirements.

Emerging picture regarding intra-agency systems in Nigeria

There is a considerable variation in the use of intra-agency systems and the availability of information. This variation is evident both vertically (i.e. within the three spheres of government) as well as horizontally (i.e. within a given sphere of government). At the FERMA end of the spectrum, all the necessary systems are already in place. At the local municipality end of the spectrum. there often is a wide variation regarding systems and information, ranging from a situation of well-developed systems to one with no systems at all.

Situation regarding an inter-agency system

At present, there is custom-made inter-agency system at (FERMA) set up for the particular purpose of coordinating activities relating to the Nigerian road network (or any selected subset thereof) at the strategy level. However, there is lack of appropriate key performance indicators for the Nigerian road network.

5.2 Recommendations

From the above, it is evident that a number of actions are needed to ensure that the necessary systems are put in place and that the required information for managing the road network is made available to decision-makers. These actions are discussed below.

Responsibility for information and decision support systems

Assigning responsibility for all aspects regarding setting up and maintenance of information and decision support systems in all spheres of government is a prerequisite for the success of these actions. In terms of Section 6(1) of the National Land Transport Transition Act, 2000 (Act No. 22 of 2000), this responsibility is assigned to the Minister of Transportation. This section reads as follows: "The Minister must develop, establish and maintain a national information system with regard to land transport, based on sound business processes and, in collaboration with the provinces, integrate that system with the information systems kept by provinces". To ensure optimal service delivery of the road network, it is necessary that this process be initiated as soon as possible.

Framework for intra-agency systems

A framework and associated guidelines for setting up intra-agency systems should be developed to assist those agencies where such systems have not yet been introduced. Guidelines should address issues such as the sub-systems needed for the different spheres of government, types of information to be collected, frequency of updating of information, development of key performance indicators and standardization (in particular regarding definitions, road classification system and format of output). Where guideline documents have already been prepared, they should be revised where necessary to reflect the current Nigerian context and address unique Nigerian needs.

Need for training

Training should be provided on an on-going basis to ensure that individuals in road agencies in the different spheres of government are capacitated with respect to the setting up and maintenance of the required systems. Training should involve the provision of guidelines and manuals, as well as courses. Training needs should be monitored on an on-going basis.

Need for enforcement and funds

Procedures should be put in place to ensure that information and decision support systems are implemented in the different spheres of government. Where necessary, funds should be made available to assist road agencies.

Need for monitoring and evaluation

The implementation process should be monitored and evaluated on an ongoing basis. Where necessary, adjustments should be effected.

Management and decision support systems

It is apparent that the first step towards the improvement of the service delivered by the country's road network (both surfaced and gravel) is to get consistent and effective condition and performance monitoring in place to afford management and effective decision support system.

Key performance indicators

Intrinsically linked with Decision Support Systems is the need to develop appropriate key performance indicators for the Nigerian road network, linked to the functional classification of roads.

REFERENCES

Kincaid, Peter (1986). The Rule of the Road: An International Guide to History and Practice. Greenwood Press. ISBN 0-313-25249-1.

Lay, Maxwell G (1992). Ways of the World: A History of the World's Roads and of the Vehicles that Used Them. Rutgers University Press. ISBN 0813526914.

Oduwole, O. S. V. (2002): Bills for Engineering Measurement & Evaluation. Vintage Books ISBN 978-35153-5-7

Oduwole, O. S. V. & M. C. Arimanwa (2003): Engineering Construction Technology – A concise introduction. Vintage Books ISBN 978-35153-7-3

Oduwole, O. S. V. & Lanre Alyegoro (2006a): First Quarterly (January – March, 2006) progress report on Federal Roads in Rivers State, Lans Consult, Unpublished March.

Oduwole, O. S. V. & Lanre Alyegoro (2006b): Second Quarterly (April – June, 2006) progress report on Federal Roads in Rivers State, Lans Consult, Unpublished June.

Oduwole, O. S. V. & Lanre Alyegoro (2006c): Third Quarterly (July – September, 2006) progress report on Federal Roads in Rivers State, Lans Consult, Unpublished September.

Oduwole, O. S. V. & Lanre Alyegoro (2006d): Fourth Quarterly (October – December, 2006)

progress report on Federal Roads in Rivers State, Lans Consult, Unpublished December.
Oduwole, O. S. V. & Lanre Alyegoro (2008a): Consultants Report to FERMA, Vol. 1, Lans Consult, Unpublished, July.
Oduwole, O. S. V. & Lanre Alyegoro (2008b): Consultants Report to FERMA, Vol. 2, Lans Consult, Unpublished, August.
Oduwole, O. S. V. & Lanre Alyegoro (2008c): Consultants Report to FERMA, Vol. 3, Lans Consult, Unpublished, September.
Oduwole, O. S. V. & Lanre Alyegoro (2008d): Consultants Report to FERMA, Vol. 4, Lans Consult, Unpublished, October.
Oduwole, O. S. V. & Lanre Alyegoro (2008e): Consultants Report to FERMA, Vol. 5, Lans Consult, Unpublished, November
Oduwole, O. S. V. & Lanre Alyegoro (2008f): Consultants Report to FERMA, Vol. 6, Lans Consult, Unpublished, December.
Oduwole, O. S. V. & Lanre Alyegoro (2008g): Effective Road Maintenance of Rivers State Roads – Consultants Final/Exit Report to FERMA, Lans Consult, Unpublished, December.
O'Flaherty, Coleman A. (2002). Highways: The Location, Design, Construction & Maintenance of Road Pavements. Elsevier. ISBN 0750650907.
Nwariaku, M.S.C. (2009): Principles and practice of road maintenance, NSE Pub. Nig. ISBN 978-900-282-5

AUTHORS' PROFILE:

*Engr. O. S. V. Oduwole, FNSE is the Deuty Director of Entrepreneurship at the Federal Polytechnic, Nekede, Owerri. A fellow of the NSE, he has served NSE at different positions both at the Owerri Branch and National Council Committees. He was PRO, Social Secretary, Technical Secretary and Vice Chairman of NSE Owerri Branch at different times and later Chief Examiner of NSE at Owerri Centre. He is the principal Partner of Wolex Vintage Technologies LTD.

** Engr. Benjamin Ekwueme, FNSE is currently a committed member of Owerri Branch of NSE. He was Special Adviser to the Imo State Governor on Projects for 7years and Managing Director, Bureau of Projects Monitoring in Imo State for 5 years before becoming the Hon. Commissioner for Public Utilities in Imo State. He is experienced in construction and maintenance of roads and other infrastructure.

*** Engr. Lanre Aiyegoro is the Principal Partner of LANS Consult. He has practiced engineering construction and consultancy for over three decades in Nigeria. He is a committed and very old member of the Nigerian Society of Engineers in Lagos State.