THE ASSOCIATION FOR CONSULTING ENGINEERING IN NIGERIA (ACEN)

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CONTENTS

FROM THE EDITORIAL SUITE

Engr. Ademola Adeboya, MNSE

Transportation of man, goods and services from one point to another is an important aspect of the economic system of nations. A core component of this transportation is the use of highways or roads. This edition of "The Consulting Engineer" magazine focuses on **"Highway Engineering Services".** In the first article, Engr. (Dr.) Sanmi Bankole, FNSE, CEO of Sanol Engineering Consultants Ltd, addresses the subject "Conventional Classification of Highways in Nigeria". This article provides our readers a clear understanding of the various classes of highways in Nigeria and their characteristics. Following this is the article on 'Highway Development Policy & Implementation in Nigeria" by Engr. Ebere Izunobi, FNSE, who currently serves as the Assistant Director, Highway Planning, Federal Ministry of Works & Housing (FMW&H). This is a vast educative material for our readers.

Other articles presented are as follows:

- Environmental & Social Impact Assessment for Highway Projects by Engr. Idowu Aderibigbe, MNSE, Principal Partner, Joint Konsult
- Comparative Analysis of Concrete & Asphalt Roads by Engr. Lanre Sagaya, Jr., Director, YOLAS Consultants Ltd
- Quality Control in Highway Construction by Engr. Kolawole Ojo, CEO, Opiq Consultancy Services
- Electrification Project Execution for Highways by Engr. Marcus Olaniyan, MNSE, Partner, Tacas Associates
- Drainage Systems Design & Execution for Highways by Engr. Henry Okpala, FNSE, Principal Consultant, HECON Consultants

In the Special Supplement section, two firms with unique and outstanding history in engineering consultancy are featured. The first one is Etteh Aro & Partners Limited. The history of highways in Nigeria would be incomplete without the mention of Etteh Aro & Partners with over 50 years in practice and more than 1,000 executed projects to its credit. The second firm, Morgan Omonitan & Abe Ltd, also has a very rich history of consultancy in Nigeria. The firm celebrated its 50th anniversary on July 3, 2022. The Editorial Board heartily congratulates this outstanding firm which is a shining example of indigenous expertise in engineering practice.

Other firms interested in featuring their services and products should send enquiries to acenmagazine@acen.org.ng. **"The Consulting Engineer" Personality** for this edition is Engr. Adekunle Olumuyiwa Mokuolu, FNSE, Past President of the Nigerian Society of Engineers. Engr. Mokuolu is an icon in the engineering family and the young as well as the older engineers have a lot to learn from him. Please read his profile and his word of counsel for young engineers.

In this edition, we have also served our readers with the photos of the following events conducted by ACEN:

i. 28TH Annual FIDIC Africa Infrastructure Conference in Lagos
ii. Extra-Ordinary General Meeting 2022
iii. Business Evening

In the Tit-Bits Column, Engr. Enefiok Ubom, FNSChE, makes a presentation on "Plastic Highways". The use of plastic is a relatively new technology in highway construction. Policy makers need to check this out and see how best this technology can be deployed in an environmentally friendly way in Nigeria.

Finally, we are grateful to the various contributors to this edition. The successful publication of this edition is our collective success.

One of our prayer points is "Safety on our Highways".

Stay safe, travel safe. Relax and enjoy your reading.

Engr. Ademola Adeboya, MNSE
(Chairman, Editorial Board)

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THE ASSOCIATION FOR CONSULTING ENGINEERING IN NIGERIA (ACEN)

The Association for Consulting Engineering in Nigeria, ACEN, was founded in 1971 and registered in 1979. ACEN is a body of registered independent private engineering consultancy firms and voice of the profession in Nigeria.

MISSION STATEMENT

"ACEN shall build a strong membership that fosters equal opportunities, creates competitive advantage through increased visibility with strategic partners and improves the standards of consulting engineering in line with international best practice".

VISION STATEMENT

"To remain the ultimate reference business association of choice for organisations providing professional engineering consultancy services in Nigeria."

FUNDAMENTAL OBJECTIVES

- Ensure that the highest level of technical competence and business ethics are brought to bear on the practice of the profession in Nigeria.
- Ensure that every State has the highest level of Consulting Engineering practice by having members in every state of the federation and the federal capital.
- Increase the number of engineering firms in the country relative to the size of the nation.
- Ensure that stakeholders in the built environment get maximum value for their investments by monitoring standards of practice within the industry.
- Grow the industry by promoting the growth of large consulting engineering firms.

ACEN MEMBERSHIP

Prior to December 2007, ACEN membership was open to individual and firm members, who possessed the required experience and professional integrity. At the 2007 AGM, a motion was passed limiting ACEN membership to firms. This was to further emphasize the business nature and focus of the association. Membership is therefore now open to Consulting Engineering firms with the adequate experience and commitment to continuous improvement in technical and business integrity. Today, ACEN's member firms numbering about 300 are located in the six geo-political zones and the FCT.

ACEN & COREN

The Council for the Regulation of Engineering in Nigeria is the statutory body with responsibility for the regulation of all Engineering activities in Nigeria. It is empowered to keep a register of all Engineering craftsmen, technicians, technologists, Engineers and Consulting Engineering Firms who wish to practice in the country. No individual or organization is allowed to practice Engineering in Nigeria without the approval of COREN. Thus, all member firms of ACEN must be registered with COREN and the members of such firms must also be individually registered by COREN.

ACEN has just recently been mandated by COREN to register on its behalf all consulting engineering firms in the country. Furthermore, ACEN President now seats on the Council of COREN. Thus, ACEN is now better positioned within the built industry.

ACEN & NSE

The Nigerian Society of Engineers is the umbrella association of all graduate Engineers in Nigeria and all Engineers employed in ACEN member firms are members of NSE. Conversely, most members of NSE with interest in Consulting Engineering practice are members of ACEN. ACEN focuses only on the business interest of Consulting Engineering Firms and her interest is, therefore, specific and complementary to the scope of COREN and NSE.

ACEN & FIDIC

The International Federation of Consulting Engineers is a 102-member organisation which provides the strongest platform for our international activities. FIDIC is the voice of Consulting Engineering all over the world, and this it does through seven major focus areas: Representation, Business Practice, Ethics/Integrity, Image, Sustainability, Globalization and Quality.

FIDIC is perhaps best known for its contracts documents, which are used all over the world, especially for international projects in the third world. The documents are used extensively by the Nigerian Federal Ministry of Works. In addition, FIDIC has Manuals on a Guide to Practice that teaches best practice in Consulting Engineering, Business Integrity Management and Quality Management amongst several others.

Two (2) ACEN members, Engr. J.I. Folayan and Engr. Bayo Adeola have served on the FIDIC Executive Committee, the highest level of the organization. Other ACEN members have served on committees and task forces of the organization, and members attend the yearly annual conferences in large numbers regularly.

ACEN & FIDIC Africa

FIDIC Africa is the FIDIC Group of African Member Associations which addresses specifically, African concerns. FIDIC Africa currently has 14 members, holds regular annual conferences and AGMs, and promotes networking among its members. Nigeria played a very active role in the formation of FIDIC Africa and has continued to be very active in the association.

ACEN former President, Engr. (Mrs.) Mayen Adetiba has served on the Executive Committee. Presently, ACEN's past president, Engr. Charles 'Yele Akindayomi, FNSE, and the immediate past President (IPP), Engr. George Okoroma, are members of the FIDIC Africa Executive Committee.

ACEN ACTIVITIES

ACEN provides a series of activities tailored to deliver service and benefits to our members in these key areas:

- Training through the ACEN School of Consulting Engineering.
- AGM & EGM for effective dissemination of information to members.
- Attending International Conferences. Membership / Certifying Standards.
- Advocacy.
- Quarterly Business Evening meetings to discuss topical issues affecting members.
- The Young Professionals Forum.
- Triannual publication of "The Consulting Engineer" magazine.
- Monitoring and follow-up on policies and bills relating to matters of engineering practice.
- Legal retainership program to advise members on legal issues.
- Advancing the practice of consulting engineering for favourable business environment for members.

- **Setting up of Special Task Forces on:**

Collapse of buildings, conditions of engagement/ scale of consultancy remunerations, quackery, Industry study, formation of built industry transparency initiative, local content for the construction industry, etc.

CHALLENGES OF ACEN

Despite the fact that ACEN has been in existence for fifty-one (51) years, some of the challenges leading to its formation have remained while new ones have emerged. The most notable current challenges are as follows:

- Unfavourable Government procurement policies especially in the states.
- Private sector perception.
- Loss of Engineers to other sectors due to low remunerations.
- Number, size and scope of ACEN Member firms.
- Delayed payments to members.
- Limited awareness and knowledge of the savings consultants contribute to the overall cost of projects if employed by governments and entrepreneurs.
- Inadequate corporate sponsorship to enhance smooth operations of the organisation.

CONVENTIONAL HIGHWAY CLASSIFICATION IN NIGERIA

BY ENGR. (DR.) SANMI BANKOLE

1.0 SYNOPSIS

In line with the title, this article focuses on conventional highway classification in Nigeria. It also justifies the need for classification of highways. It elucidates on classes of highways and their different characteristics. It also provides the benefit of highway classification in relation to national development. In order to enlighten the reader more vividly, this paper gives a comparison between conventional highway classification in India and the United States of America.

Engr. (Dr.) Sanmi Bankole, FNSE, FNIHTE, FIICA, M. ASCE (CEO, Sanol Engineering Consultants)

2.0 INTRODUCTION

A road is defined as a paved way, access, route or a thorough-fare, which takes a person from one destination to another. Roads have two main functions: to provide avenue for mobility and land access.

3.0 CONCEPT OF ROAD CLASSIFICATION IN NIGERIA

Classification is the tool by which a complex network of roads can be subdivided into groups having similar characteristics. The classification of roads into different operational systems, functional classes or geometric types is necessary for communication between engineers, administrators and the public.

The principal purposes of road classification are to:

- Establish logical integrated systems that, because of their particular service, should be administered by the same jurisdiction
- Relate geometric design control and other design standards to the roads in each class
- Establish a basis for developing long range programmes, improvement priorities and financial plans.

In any classification system, the division between classes is often arbitrary and consequently, opinions differ on the best definition of any class. In India for instance, roads are classified based on:

i. Speed and accessibility in terms of freeways, expressways, highways, arterials, local streets and collector roads
ii. Construction materials used in terms of earthen road, gravel roads, murram roads, kankar roads, water bound macadam (WBM), bituminous roads and cement concrete roads
iii. Indian Authority (Nagpur) in terms of national highways, state highways, district roads and village or rural roads
iv. Classification based on road usage in terms of all-weather roads and fair-weather roads
v. Classification based on carriageway in terms of paved roads and unpaved roads
vi. Classification based on rigidity in terms of flexible roads and rigid roads
vii. Classification based on topography in terms of hilly roads and plain area roads
viii. Classification based on economy consideration:, low-cost roads, medium-cost roads and high-cost roads
ix. Classification based on traffic volume in terms of low traffic roads, medium traffic roads and high traffic roads
x. Classification based on traffic types: in terms of cycle tracks and pedestrian tracks

In the United States of America, roads are classified based on the American Association of State Highways and Transportation Officials (AASHTO) design criteria, which Nigeria as a sovereign State, subscribes to. It is the most widely accepted design type criteria.

Based on AASHTO design criteria, roads can be classified as:

i. Freeways
ii. Arterial roads other than freeways
iii. Collector roads

For each classification, specific design standards, criteria, access and other policies have been developed and applied. Each classification has the roads grouped into similar functions. The factors that influence the classification of a road to a certain group are:

- Trip purpose (for majority of users)
- Trip length

"In Nigeria, however, roads are generally classified based on two major criteria, namely ownership and functionality."

- Size and type of population centre served
- Traffic characteristics
- Network and system requirements

In Nigeria, however, roads are generally classified based on two major criteria, namely ownership and functionality.

i. Ownership: This refers to the organization that owns or financed the road. Under this classification are federal roads/highways, state roads, local roads, private roads/drives or estate roads and rural roads

ii. Functionality: Road performs two major functions, which are: avenue for mobility and access, which imply that, a road enables people and goods to move from one destination to another and enables people to gain access to their landed properties. By functionality, roads are classified by:

- design types based on the major geometric features (example freeways)
- Route numbering, for road traffic operational purposes
- Administrative classification, which denotes the tier of government responsible for, and the method of, financing road facilities
- The grouping of roads by the type of service they provide. This is referred to as functional classification and it is helpful for transportation planning purposes.

"These roads are owned, constructed, regularly maintained and serviced by the Federal Government. The numbers of Federal roads in Nigeria are many because..."

4.0 CLASSES OF ROADS IN NIGERIA

Roads in Nigeria can be divided into the following classes according to their major function in the road network:

Class A: National Trunk Roads

These are roads that link state (provincial) capitals, main centres of population and nationally important centres. Their major function is to provide avenue for mobility, by connecting one state to the other, thereby allowing people to move and transport themselves and for movement of goods and services across the country. They have longer trip lengths. They are designed to provide a high level of service with a high design speed.

This class of roads can be freeways, expressways, dual carriageways or 2-lane single carriageways with minimum design speed of 100km/h and average daily traffic (ADT) of 15,000 – 20,000veh/d. The average travel distance of trips on these roads is more than 2 hours in duration. This kind of road is constructed in Nigeria for uninterrupted movement of traffic and vehicles moving more freely at high speeds and pedestrians are hardly seen walking on foot using such roads.

These roads are owned, constructed, regularly maintained and serviced by the Federal Government. The number of Federal roads in Nigeria are many because the Federal Government currently implements a policy of providing Class A Roads to cover each State of the Federation.

2-Lane single carriageway road is a very popular kind of road in Nigeria. This road has a single lane on either direction, with no concrete median barrier in place to demarcate the road. The motorists who ply this 2-lane highway in Nigeria drive with caution, in order to avoid collision.

On the other hand, dual carriageway road is the type of road, which has two lanes on either direction, i.e. (a speed lane and a service lane, with concrete median barrier between the lanes. These roads allow

Fig. 1: *A Dual carriageway with concrete crash*

Fig. 2: *A freeway with control of access and median*

Fig. 3: *A dual carriageway for a road network*

Fig. 4: *A 2-lane single carriageway, a federal road continuity in rural areas*

for easy movement of traffic in opposite directions and reduce the likelihood of the occurrence of a road accident (See Figs. 1, 2, 3 & 4).

Class B: Primary Roads

These are roads linking provincially important centres to each other or to a higher-class road or urban/rural centres. They provide connection between districts' local centres of population and development areas with higher class road. Their functions are to provide both avenues for mobility and land access. They accommodate short trips and feed class A roads. For this class of roads, an intermediate design speed and level of service is required. These roads are constructed as 2-lane single carriageways, with minimum design speed of 80km/h and ADT of 8,000-10,000veh/d.

These types of Nigerian roads are owned, constructed and maintained by the State Governments, using state funds; in order to ensure that various local governments and towns in the states are connected, for people, goods and services to move freely.

Class C: Secondary Roads

Class C roads link locally important centres to each other, to a more important centre or to a high-class road (rural/market centres). They provide linkages between locally important traffic generating centres and their rural hinterland; they function to provide both avenue for mobility and access. They are also designed to accommodate short trips and require intermediate design speed and service.

They are constructed as 2-lane single carriageway roads, with minimum design speed of 80km/h and ADT greater than 4,000veh/d

Class D: Minor Roads

These are roads linking to minor centres (market/ local centres) and all other trafficable roads. They serve primarily as access to land adjacent to the secondary road system. These classes of roads have shorter trip lengths. Design speed and level of service considerations for these roads are low. The minimum design speed of these roads is 40km/h. These roads are devoid of major activities and are often referred to as district roads. They aid movements between local Government Headquarters or districts and are built and maintained by the LGA or district communities.

5.0 CONTROL OF ACCESS

Uncontrolled access to road side developments along roads whose major function is to provide mobility will result in an increased accident hazard, reduced capacity and early obsolescence of the roads.

FUNCTIONAL CLASS	CLASSIFICATION	LEVEL OF ACCESS CONTROL	
		Desirable	Reduced
A	National Roads	Full	
B	Primary Roads	Partial	Partial or Unrestricted
C	Secondary Roads	Partial	Unrestricted
D	Minor Roads	Partial or Unrestricted	Unrestricted

Table 1: *Access control by functional class of roads*

"Roads of higher classes have their major function..."

Therefore, in order to preserve major roads as high standard traffic facilities, it is necessary to control access by the supervising Authority.

The following are the three levels of access control that can be applied on a major road:

i. Full access control: This means that the authority to control access is exercised to give preference to through traffic, by providing access connections with selected public roads only and by prohibiting direct access connections to all other roads.
ii. Partial access control: It means that the authority to control access is exercised to give preference to through traffic to a degree in that, in addition to access connection with selected public roads, there may be some private access connections.
iii. Unrestricted access: This implies that preference is given to local traffic, with the road serving the adjoining areas through direct access connections. However, the detailed location and layout of the accesses should be subject to approvals by the supervising Authority in order to ensure adequate standards of visibility, surfacing, drainage, etc.

Road function determines the level of access control needed. Roads of higher classes have their major function to provide avenue for mobility, while the function of lower classes of roads is to provide land access.

For all purpose roads, the following general guidelines in Table 1 above are given for the level of access control in relation to the functional road classification.

"Design speeds are very important for the safety of road users and it is on some way dependent on..."

6.0 MINIMUM DESIGN SPEED DESIGNATION OF SOME ROADS

Design speed is one among the important criteria used for geometrical design of roads. Design speeds are very important for the safety of road users and it is in some way dependent on the access level of the road. Roads with high access require low design and vehicle operating speed to avoid accidents while roads with limited access may be designed with high speed to save cost, time and for faster mobility.

7.0 BENEFITS OF HIGHWAY CLASSIFICATION IN NIGERIA

i. It assists the government's internal planning and prioritization of budgetary provisions for funds to be spent on road infrastructure.
ii. Classification of roads allows grants to be determined and fixed.
iii. It provides Civil Engineers with information they can use to improve the transportation system.

8.0 CONCLUSION

Classification of roads in Nigeria provides a basis for orderly development of road infrastructure.

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HIGHWAY DEVELOPMENT POLICIES AND IMPLEMENTATION

BY ENGR. EBERE IZUNOBI

Engr. Ebere Izunobi, *FNSE (Assistant Director, Highway Planning, FMW&H)*

1.0 INTRODUCTION

The highway infrastructure is an intrinsic part of every community because of its door-to-door accessibility and capacity to boost societal development. It is an important aspect of the transport infrastructure that promotes integration and economic development of any society. It plays a significant role in regional growth and competitiveness by connecting local producers to international markets. In Nigeria, the road sector is dominantly used for transportation as it accounts for over 90 percent of movememt of people and goods. This utility makes road infrastructure a vital component for stimulating economic growth.

A functional road network lowers business cost and reduces the time of moving goods and services to where they are required. Hence, it spurs growth and increases the size of markets which is a precondition for realizing economies of scale. Road transport can contribute to the economy directly through addition to capital stock via increases in transport infrastructure. In addition, roads provide arteries through which the economic life of the people, information and raw materials as well as finished products can be moved from one place to another.

The importance of this sector is why it has been prioritized in each development plan from 1962 to the present Economic Recovery and Growth Plan (ERGP) which commenced in 2017 and the National Development Plan (2021-2025).

For clarity, the words 'Highway' and 'Road' will be used interchangeably in this write-up as they have similar meanings. It is primarily defined as a travelled way leading from one place to another, especially one with a specially prepared surface which vehicles can use. In this context, bridges on the roads serve the same function. The Cambridge Dictionary defines it as "a long, hard surface built for vehicles to travel along".

2.0 BRIEF HISTORY OF ROAD DEVELOPMENT IN NIGERIA

Findings indicate that the documented history of road development in Nigeria dates back to 1904 when Lord Lugard attempted the construction of a mule-road linking Zaria and Zungeru in the Northern States of Nigeria. However, the earliest motorable roads in Nigeria were constructed in 1906 to link Ibadan and Oyo followed by the road linking Lagos and Abeokuta constructed in 1926 with bituminous surface. Road development was then facilitated by the setting up of a Road Board by the Central Government in 1925. In 1926, H.E. Walker proposed a skeleton trunk road system to link the major administrative centres in the country.

In 1960 (Nigeria's year of independence), the country had a growing network of trunk roads as well as secondary and feeder roads that were meant to facilitate the evacuation of agricultural produce from the hinterland to the ports for exports. They also served as links between scattered human settlements thus permitting ease of administration. The roads were designed as a frame upon which the network of secondary roads could be built thus enabling the general road system to be considered as a coordinated whole¬ rather than as a jigsaw of small disjointed sections.

Information from the various publications of the Federal Office of Statistics in Nigeria show that as at 1951, out of the total of 44,414 km of roads in Nigeria, 1,782 km were surfaced but they were lacking in standard designs, characterized with sharp bends and poor drainage system and having single lanes. The total road length increased from 44,414 km in 1951 to 114,768 km in 1980. While tarred roads increased in length from 1,782 km in

"...Statistics in Nigeria show that as at 1951, out of the total of 44,414 km of roads in Nigeria, 1,782 km were surfaced but they were lacking in standard designs..."

1951 to 28,632 km in 1980, earth/gravel roads increased from 4,232 km in 1951 to 86,136 km in 1980.

The current total road network in Nigeria is estimated to be 200,000km with 35,000km (17.5%) owned by the Federal Government, 16.5% by the State Governments and the balance of 66% by the Local Governments. Out of this stock of 200,000km, about 65,000km or 33% are paved and Nigeria ranks second to South Africa (362,099km) in Sub-Saharan Africa in terms of road network coverage.

3.0 POLICIES FOR ROAD DEVELOPMENT AND IMPLEMENTATION

Nigeria has over the years evolved policies that have shaped the development of the nation's highway network. These policies outline the administrative procedures, provide guidelines for implementation of various aspects of highway development and assist in decision making.This paper will concentrate on policies that pertain to Federal Highways which form the backbone of road transportation in the country. The policies at the Federal level guide the other tiers of Government in developing their own.

The current policies of highway development in Nigeria are broadly encapsulated in the Nigeria Integrated Infrastructure Master Plan (NIIMP), the Economic Recovery and Growth Plan (ERGP) and the most recent National Development Plan (2021-2025). The specific policies for the road sector have been grouped into 4 categories as described hereunder:

3.1 FUNDING POLICIES

These are policies designed by the government to enhance the funding of road development apart from annual budgetary provisions. The policies that have been used in recent times are described below:

i. **Petroleum (Special) Trust Fund (PTF):** The Petroleum Trust Fund was established by Decree No. 25 of 1994 by the Abacha regime to receive monies from the sale of petroleum products less the approved production cost. One of the sectors that benefitted from the fund is the road sector. The PTF embarked on road projects that cut across the 6 geopolitical zones of the country. Though visible achievements were withnessed in the road sector during the PTF era, it was scrapped in 2000 by the new democratic government because it was not in the constitution. Research by some scholars inferred that the PTF perfomed well in achieving its objectives but not without pitfalls.

ii. **Subsidy Reinvestment and Empowerment Programme (SURE-P):** The SURE-P policy was used as an intervention program with the announcement of subsidy removal on petrol by the Jonathan Administration on 1st January, 2012. It was designed to complement all the other development programs of the 3 tiers of government and specifically to mitigate the immediate impact of the petroleum subsidy removal on the populace. The intervention areas were the social safety net projects and infrastructure development projects. The road sector was seen as a critical component of the infrastructure aspect of SURE-P.

SURE-P channeled a total sum of N211,196,753,926.47 towards rehabiltation of federal roads and bridges across the country as shown in Table 1. One of the positive outcomes of this policy was the reduced travel time achieved by motorists as shown in Table 2. SURE-P also channeled resources to road maintence through Federal Roads Maintenance Agency (FERMA). The program provided jobs for local residents along the project corridor for minor routine maintenance without incurring huge costs in procurement processes and contract awards.

S/N	AMOUNT EARMARKED (N)	AMOUNT DISBURSED(N)	YEAR
1	85,500,000,000.00	28,360,258,355.13	2012
2	93,500,000,000.00	78,636,495,571.34	2013
3	92,993,402,030.56	104,200,000,000.00	2014
TOTAL	**271,993,402,030.56**	**211,196,753,926.47**	

Table 1: *Ependiture on Highways SURE-P Projects for years 2012, 2013 & 2014 (Source: FMWH)*

ROUTE	TRAVEL TIME IN 2011 PRIOR TO SURE-P	TRAVEL TIME IN 2015
Abuja - Abaji - Lokoja Expressway	4 hours	2 hours
Benin - Ore - Shagamu - Lagos Expressway	9 hours	4 hours
Lagos - Ibadan - Ilorin Highway	6 hours	3.5 hours

Table 2: *Reduced travel time (Source: FMWH)*

Though the SURE-P proved to be a game changer by achieving effectiveness in roads contruction and maintenance, it was discontinued by the new government in 2015.

iii. Presidential Infrastructure Development Fund (PIDF)

The Federal Government established the PIDF in 2018 to accelerate the delivery of some critical and strategic infrastructure projects. For the road sector, the projects selected include Lagos - Ibadan Expressway, 2nd Niger Bridge with access roads and Abuja – Kaduna - Kano Road. These are arterial routes on the Federal Roads network that carry significant traffic reaching an average daily traffic (ADT) of over 10,000 vehicles per day.

The PIDF is being managed by the Nigeria Sovereign Investment Authority (NSIA) with the mandate to complete the projects on schedule and on budget. NSIA is also expected to champion the commercialization of the roads when completed in order to recoup the investment and ensure efficient and sustainable management of the road assets. The basic information on the PIDF road projects is shown on Table 3.

S/N	DESCRIPTION	CONTRACTOR	CONTRACT SUM	LENGTH
1	Lagos-Ibadan Expressway	Julius Berger Nig. Plc (Section I) Reynolds Construction Company (Section 2)	N311.4bn	127.6km
2	Second Niger Bridge	Julius Berger Nig. PLC	N206.2bn	1.6km Bridge 10.3km approach roads
3	Abuja - Kano Expressway	Julius Berger Nig. PLC	N655.2bn	375km

Table 3: *PIDF Projects (Source: NSIA)*

iv. Road Infrastructure Tax Credit Scheme (RITC)

The Road Infrastructure Tax Credit (RITC) Scheme is an innovative funding strategy developed to leverage on private sector financing in Nigeria to address the country's road infrastructure deficit. The framework for implementing the RITC Scheme is encapsulated in the Executive Order No. 007 of 2019 on the Road Infrastructure Development and Refurbishment Investment Tax Credit Scheme.

A Management Committee was put in place to administer the scheme which is chaired by the Honourable Minister of Finance while the Honourable Minister of Works and Housing is the Deputy Chairman.

The program involves forming partnership with the private sector to fund selected road projects. Funds expended by the partner companies on the road projects would be used as credit against their Company Incom Tax. The RITC Scheme is designed to be in force for a period of ten (10) years from the date of its commencement. Forty (40) highway projects are currently being funded with over N1 trillion under the RITC Scheme. Major players in the scheme include Dangote Industries, Nigerian Liquified Natural Gas Limited (NLNG), BUA Group, Nigeria National Petroleum Corporation Ltd (NNPCL), MTN Nigeria Telecommunications Ltd.

v. SUKUK Bond

One of the instruments that has been used by the Nigerian Government to increase the road infrastructure stock is the Sovereign SUKUK Bond. In Nigeria, SUKUK is a recent term though it has been used by many countries such as Bahrain, Indonesia, Saudi Arabia, Singapore, Somalia, Turkey, UK, Hong kong, Egypt, Senegal, South Africa, among others, to fund projects.

In summary, SUKUK is an Arabic word, that refers to investment certificates or notes which signify proportionate interest in ownership of tangible assets, usufructs and services or investment in the assets of particular projects or special investment activity that adhere to the principles of Sharia. It is a component of Islamic finance that is a non-interest based investment and financing instrument but its application is not restricted to Muslims. The total sum of N576.11bn SUKUK fund has been deployed to fund highway projects broken down thus: 2017(N100bn), 2018(N100bn), 2020(N165.55bn) and 2021(N210.56bn).

vi. **Infrastructure Corporation of Nigeria Limited (Infraco)**
The creation of the Infrastructure Corporation of Nigeria Limited (Infraco) was approved by President Muhammadu Buhari in 2021. The establishment is expected to bridge the wide infrastructure funding gap with a seed capital of N1 trillion, being equity contributions of the Central Bank of Nigeria (CBN), African Finance Corporation (AFC) and the Nigerian Sovereign Investment Authority (NSIA).

The seed money is part of the targetted N15 trillion required to bridge the infrastructure funding gap. The balance of N14 trillion is planned to be substantially sourced from domestic sources such as idle funds with pension administrators and similar funds within the country as well as funds from interested foreign investors. The funds would be utilised to support the Federal Government in building the transport infrastructure required to move agriculture products to processors, raw materials to factories and finished goods to markets. Application of this fund to road development is yet to commence.

"The seed money is part of the targetted N15 trillion required to bridge the infrastructure funding gap. The balance of N14 trillion is planned to be substantially sourced from domestic sources such as idle funds with pension administrators and similar funds within the country as well as funds from interested foreign investors."

vii. **Fuel Tax**
Fuel tax was designed to provide sustainable funding for road maintenance. The collection of fuel tax for road development commenced in Nigeria after the enactment of the Federal Roads Maintenance Agency (FERMA) Act in 2004. This involved the collection of 5% user's charge on pump price of petrol and diesel of which 40% will accrue to FERMA and 60% to be utilised by the established State Roads Maintenance Agencies. This policy was abandoned prematurely due to a court ruling and strike action by Nigerian Labour Congress.

3.2 PROJECT EXECUTION POLICIES

These are policies designed to improve project delivery with reduced effect on the environment and to prevent waste in the deployment of project resources. They include Certification and Payment for only Protected Works, Use of Bitumen Emulsion, Use of Modified Bitumen for heavily trafficked arterial roads. These policies are explained below:

i. **Certification and payment for only Protected Works**
In the time past, contractors executing Federal Highway projects were paid based on interim certifications for work done. This posed some challenges in situations when aspects of the project like earthworks have been executed and paid for by the Government and later washed away by rain. In 2016, the then Minister of Works & Housing under the administration of President Goodluck Ebele Johnathan came up with a policy that only protected works executed on a highway project would be paid for by the Government to avoid double payment. It implies that works executed must be protected from possible damages by normal weather elements before it can be paid for.

ii. **Use of Bitumen Emulsion**
In 2012, the Federal Ministry of Works stopped the use of cut-back bitumen made by mixing kerosine with bitumen mainly used for tack coat and prime coat in road construction. In its place, the bitumen emulsion was introduced. Bitumen emulsion is a liquefied type of bitumen

with a low viscosit. The use of bitumen emulsion reduces energy consumption and emissions of greenhouse gases and ultimately protects the environment.

iii. **Use of Modified Bitumen for Heavily Trafficked Arterial Roads**
One of the innovations introduced to improve the service life of Federal roads (which carry about 70% of freight of goods and passengers in the transportation network) is the use of modified bitumen for construction. The modified bitumen offers superior performance properties with resistance to rutting, cracking and fatigue without segregation. For instance, no rutting has been withnessed on the Lagos – Ibadan Highway where it has been used, unlike the Abuja – Lokoja Highway where it was not used.

3.3 FEDERAL HIGHWAY RIGHT OF WAY MANAGEMENT POLICIES

These are policies aimed at preventing the abuse of the Federal Highways Right of Way (RoW) and provide guidelines for safe use of the RoW for revenue generation such as 'Dig Once policy' for the installation of telecomunication ducts, Advertisement Regulation on the RoW, Provision of title document for the Federal Roads RoW and Axle load Regulation.

i. **Dig Once Policy for the Installation of Telecomunication Ducts**
To promote broad band penetration and ensure minimal damage to existing highway infrastructure and other utilities along the Federal Highways RoW, the Federal Ministry of Works & Housing in collaboration with stake holders developed a policy document in 2012 named ***"Guidelines for Grant of Access on Federal Highways Right-of-Way to Information and Communications Technology Service Providers (ICTSPs)".*** The document provided guidelines for installation of underground telecomunication ducts and cables. One of the key components of the document is the "Dig Once Policy".
The implementation of this policy is not fully effective due to enforcement challenges and the uncooperative attitude of telecoms companies.

ii. **Advertisement Regulation on the RoW**
The Federal Ministy of Works & Housing developed the Federal Highways (Use of Right of Way, Control and Prohibition of Advertising) Regulations in 2013, for safe use and installation of facilities along the Federal Highways RoW. The document allows the Federal Government to optimise the use of the RoW asset in a way that it would not jeopardize motorists using the roads but would generate revenue for the Federal Government. The policy allows the use of the RoW for outdoor advertising, installation of masts and laying of optic fibre for telecommunication purposes, development of trailer parks and garages and other uses that would not compromise safety of road users.

iii. **Provision of title document for the Federal Roads RoW**
The Federal Highways (Building Lines) Regulations, 1971 clearly describe the RoW for Federal Highways. Also, the Federal Highways Act Cap135 section 1(1) vests the powers of management, direction and control of Federal highways throughout Nigeria in the Minister of Works and Housing, in respect of planning, construction and maintenance, the supervision of user of such highways and the regulation of traffic thereon. One challenge is encroachment on the RoW. Also, some State Governments unknowingly allocate the RoW to the public. To discourage and forestall encroachment on the RoW, the Federal Government is gazetting

"One of the innovations introduced to improve the service life of Federal roads (which carry about 70% of freight of goods and passengers in the transportation network) is the use of modified bitumen for construction."

and providing title documents for the RoW. This equally provides a robust legal document for the RoW enforcement.

iv. **Axle Load Regulation**
In order to curb premature failure of Federal roads, the Federal Ministry of Works & Housing developed the Federal Highways (Permissible Weights and Weighbridges) Regulations in 1983. The document was revoked and replaced with the Federal Highways (Control of Dimensions, Weights and Axle Load of Heavy Duty Goods Transport Vehicles) Regulations 2018. This was occasioned by the Harmonization of Standards and Procedures for the Control of Dimension, Weight and Axle Load of Goods Vehicle within Member States of the Economic Community of West African States (ECOWAS).

The new document harmonized axle loads and dimensions to facilitate movement of heavy goods vehicles within the ECOWAS sub-region. Implementation of the new policy has fully commenced in Nigeria.

3.4 PUBLIC PRIVATE PARTNERSHIP (PPP)

This encompasses different models of Public and Private sector Partnership for the procurement of both infrastructure and services. For road infrastructure, this may involve the Private sector getting involved in each of, or a combination of funding, construction and maintenance of roads with the Public sector. Policies to promote PPP in Nigeria includes the enactment of the Infrastructure Concession Regulatory Commision (ICRC) Act, 2005 and the Tolling Policy.

"In 2005, Higerian Government passed into law the Infrastructure Concession Regulatory Commission (ICRC) Act. Leaning on the provisions of the Act, there is a clear framework for the partners..."

i. **Infrastructure Concession Regulatory Commision (ICRC) Act, 2005**
In 2005, the Nigerian Government passed into law the Infrastructure Concession Regulatory Commission (ICRC) Act. Leaning on the provisions of the Act, there is a clear framework for the partners in a PPP model to use as a basis for execution of projects. In collaboration with the ICRC, the Federal Ministry of Works & Housing has obtained an Outline Business Case (OBC) Certificate from the ICRC to proceed with the concession of 12 highways under the Highway Development and Management Initiative (HDMI). The routes represent 1,963km or 5.6% of Nigeria's 35,000km Federal roads network. They are being implemented on existing routes referred to as Brown Field. These include:

Route 1	- Benin - Asaba	-	125km
Route 2	- Abuja - Lokoja	-	193km
Route 3	- Kano - Katsina	-	150km
Route 4	- Onitsha - Owerri - Aba	-	161km
Route 5	- Shagamu - Benin	-	258km
Route 6	- Abuja - Keffi - Akwanga	-	122km
Route 7a	- Kano - Maiduguri (Kano-Shuari)	-	100km
Route 7b	- Kano - Maiduguri (Potiskum-Damaturu)	-	96.24km
Route 8	- Lokoja - Benin	-	270km
Route 9	- Enugu - Port Harcourt	-	200km
Route 10	- Ilorin - Jebba	-	129km
Route 11	- Lagos - Ota - Abeokuta	-	80km
Route 12	- Lagos - Badagry - Seme Border	-	79km

The would-be concessionaires are responsible for managing the entire RoW as well as developing the route and recoup their investments through the revenue generating assets developed on the route and tolling. The concessioning process commenced in 2021 with the launch of the Request for Qualification (RFQ) published on 29th March, 2021. It is expected to be completed in the 4th quarter of 2022. The implementation of the pilot 12 HDMI Value Added Concession (VAC) projects is a paradym shift in road development in Nigeria. If successfully implemented, the program is expected to create over 50,000 direct jobs and over 200,000 indirect jobs through construction, management and maintenance activities on the routes. It would also attract private sector investment of over N1trillion into the road sector.

ii. Tolling Policy

In order to promote and encourage private sector's participation in development and management of roads in Nigeria, the Federal Government approved the Federal Roads and Bridges Tolling Policy in August 2021. The objective is to attract additional investment from the private sector in the management, maintenance and upgrading of Federal roads and bridges through Public Private Partnerships (PPP). The costs of financing these investment will be partly met by road users through road tolls. This broad National Framework for Tolling will also serve as a guide for States and Local Governments which seek to implement their own tolling policies. Among other provisions and guidelines, the document states the toll tariff category for vehicles and vehicles to be exempted from tolling as shown in Table 4 and Table 5 respectively.

S/N	CATEGORY OF VEHICLE	
1	Light Vehicles	Small Cars
2	Semi Light Vehicles	Minibuses, Pickups, Jeeps and SUVs
3	Medium Heavy Vehicles	Luxury Buses, Two Axle Goods Vehicle
4	Large Heavy Vehicles	Goods vehicles with 3 to 4 Axles
5	Extra Large Heavy Vehicles	Goods vehicles with 5 or more Axles

Table 4: *Toll tariff categories* (Source: Federal Roads and Bridges Tolling Policy, August, 2021)

S/N	CATEGORY
1	Bicycles, Pedal Cycle, Tricycle, And Motor Cycles
2	The Armed Forces
3	The Nigeria Police Force
4	The Nigeria Fire Service
5	The Nigerian Correctional Service
6	Ambulances
7	The Nigerian Red Cross Society
8	Diplomatic Missions

Table 5: *Categories with 100% Discount on toll tariff*

4.0 CONCLUSION

Nigeria has evolved and implemented series of policies to promote highway development over the years. This paper brings to the fore the recent ones currently shaping highway development in the country. It is evident that the policies are good tools to improve the road sector but it must be said that effective implementation remains a major challenge. As part of the way forward in highway development, the Nigerian Government should work towards actualizing a strong administrative framework in the form of a "Road Authority" for the execution/ implementation of Highway policies which has been advocated since 1971 by the S. O. Wey report. Such framework being autonomous in nature would limit bureaucratic public service norms and provide a platform for effective implementation of the current/ future policies that would uplift the standard of Nigerian roads.

"...implementation of Highway policies which has been advocated since 1971 by the S. O. Wey report."

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BRIEF PROFILE

Etteh Aro & Partners (EAP) is one of the first indigenous civil engineering consulting firms in Nigeria. The firm was established on 29th of April 1970 by two founding partners, Engr. (Rev.) Ette Ikpong Etteh (OFR) and Late Engr. Lawrence Arokodare, after being trained professionally both at home and abroad, while working with Ove Arup & Partners. EAP has a dedicated team of partners who are all professional engineers with membership in top industry associations both home and abroad (COREN, N.I. Struct.E, NSE, ICE, IHE, MIABSE, amongst others). Etteh Aro & Partners has over 120 employees in 6 branches; Lagos, Ado-Ekiti, Abuja, Benin, Port-Harcourt, Uyo with Ibadan as the head office all within the country, with core business focusing on bridges, structures, highway, civil, procurement support social management plan and environmental engineering problems.

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EKITI
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LAGOS
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VISION & MISSION STATEMENTS

To maintain a leading network of professionals in Africa who efficiently and effectively provide excellent solutions to infrastructural development. To continue with the delivering of quality services to clients through systematic application of the latest and finest engineering technology.

To continue in providing institutional strengthening through training, technology transfer and mobilization of resources with focus on human resource development. Resources with a focus on human resource development.

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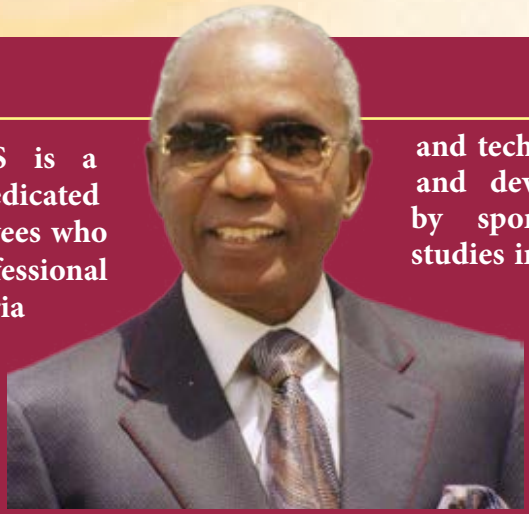
Our expertise in consultancy services is known for being excellent and we have been successful in providing engineering design, management and construction solutions on notable roadways, rural roads, bridges, retaining structures, emergency erosion and flood control work, stadia, and multi-storey buildings in Nigeria. Over the years, our services have attracted a significant number of clients which span from the federal and state ministries/parastatals, oil and gas industry, banking industry, telecommunication industry, power and energy industry and corporate organizations to private individuals.

Etteh Aro & Partners has executed an impressive list of projects locally and internationally. The firm is managed and staffed by very reputable, competent and experienced professionals 'glued' together as a team with the ultimate goal to deliver first-class services to our valued clients. The top management and other key professionals have been engaged in Engineering Consulting practice locally and internationally in the last 50 years. Etteh Aro & Partners celebrated fifty years of professional services in Nigeria in 2020.

Etteh Aro & Partners has been registered, as a partnership, under Nigerian laws since April 29, 1970 and was incorporated as Etteh Aro & Partners with Registration No. RC IBZ 030850. The firm is registered with the Council for the Regulation of Engineering in Nigeria (COREN).

OUR PEOPLE



Engr. (Rev.) Ette Ikpong Etteh, OFR
(Founding Partner, Etteh Aro & Partners)

ETTEH ARO & PARTNERS is a professional network of dedicated partners, with over 200 employees who are fellows and members of professional associations and bodies in Nigeria and abroad. We are invested in recruiting talented and qualified people who we fully equip with up to date software and equipment, working in a conducive environment so as to enable the efficient and effective execution of projects and the promotion of job satisfaction among employees. We pride ourselves in the development of our human capital as we believe that our people are our lifeblood. We therefore invest our financial and technical resources in the training and development of our employees by sponsoring their post-graduate studies in any university in Nigeria and abroad and also funding their attendance of professional conferences, seminars, workshops, examinations etc. We also conduct in-house training where seasoned facilitators and senior engineers provide practical knowledge and information to our employees. Since the establishment of the company, we have successfully trained over 500 engineers and sponsored over 50 engineers for their post-graduate studies in Universities especially universities in the United Kingdom.

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CORPORATE OBJECTIVES

- Our mission is to provide world-class quality services to our clients to enhance the reliability, availability and maintainability of facilities, civil engineering structures through designing and supervising. Our mission can be thus summarized as follows:
- Project consultancy and design, feasibility studies, engineering, management of infrastructural facilities and industrial developments.
- Project conceptualization, engineering and management in power and energy, telecommunications, oil and gas, and infrastructural facilities.
- Training and development of human resources in engineering and maintenance design.
- Preparation and evaluation of contract and Tender documents.

MAJOR SERVICES

- **Project management and monitoring**
- **Engineering design, supervision of buildings, roads and estates infrastructure**
- **Design of oil and gas structures such as tank farms, pipe layouts etc**
- **Maintenance, refurbishment of buildings**
- **Design of fluid retaining structures, multi-storey buildings and stadia**
- **Geotechnics**
- **Water resources management**
- **Environmental planning consulting**
- **Surveying**
- **Soil and Material studies for roads, buildings and other infrastructures.**

OUR HEALTH, SAFETY POLICY

ETTEH ARO & PARTNERS is committed to the highest standard of excellence in service delivery. The same commitment to excellence applies to the manner in which the company discharges its responsibilities for the health and safety of staff, contractors, visitors and all

those who may be affected by the company's activities and operations. In meeting this commitment, the company acknowledges all applicable local health and safety legislations and also global industry best practices and will take all steps within its power to provide a working and living environment which is healthy and safe for

DETAILS OF PROJECTS

Some of our projects in engineering design and supervision.

		CLIENT	STATUS
	LAGOS		
1	UBA Headquarters, Broad Street	UBA	Constructed
2	Globacom Towers (formerly Proline)	Globacom	Constructed
3	Oando Head Office (formerly Unipetrol)	Oando (formerly Unipetrol Nig. Ltd.)	Constructed
4	Federal Palace Hotel	Tourist Company of Nigeria	Constructed
	ABUJA		
5	Central Bank of Nigeria	Central Bank of Nigeria	Constructed
6	National Library	Federal Ministry of Education	Under Construction
7	Design supervision of the Outer Northern express way, Abuja (Lots 1 & 2)	Federal Capital Devel. Authority	Constructed
8	Design of katampe District Infrastucture Road, Drainage, Water supply and Waste disposal and Bridges)	NAIRDA for Deanshanger Project Limited	Design completed
9	Dualization of the Kano-Maiduguri Road and Bridges (545 km)	Federal Ministry of Works, Abuja	Design completed
	OYO		
10	Agbowo Shopping Complex, Ibadan	Ministry of Works & Housing, Lagos.	Constructed
11	Design and Supervision of Ventura Mall, Ibadan.	Stellavera Development Company Ltd.	Constructed
	ONDO		
12	Engineering studies and Designs of Agadagba-Obon-Arogbo Road/Bridge with spur to Agbabiri-Egbesubisi Phase 1, Ese Odo.	Niger Delta Development Commission (NDDC)	Under construction
	NIGER		
13	Consulting Services for the Accessment of Railway Bridge, Western line lot three and Design of Bridge 73, Western line of Bridge, Niger State.	Nigerian Railway Corporation (NRC)	Design completed
	AKWA-IBOM		
14	Akwa Ibom Stadium Complex	Akwa Ibom State Govt.	Constructed
15	Akwa Ibom International Airport	Akwa Ibom State Govt.	Under Construction
	CROSS- RIVER		
16	Metropolitan Hotel, Calabar.	Ministry of Trade & Industries, Calabar.	Constructed
17	Calabar International Convention Centre Access Road	Cross River State Government	Constructed
18	House of Assembly Quarters Rd. Network	Cross River State Government	Under construction
19	Calabar Golf Estate Rd. Network (Phase 1)	Cross River State Government	Constructed
20	Consultancy Services (Contract Mgmt. and Proj. Supervision) for the construction of Petroleum Tank FAR (Phase 1: 35,583.43 MT Capacity),Portside Ind. park, Calabar.	Knights Templar Limited	Constructed
	RIVERS		
21	NDDC Headquarters, 167, Aba Road	Niger Delta Dev. Commission	Constructed
22	NDDC Building, Eastern By-pass	Niger Delta Dev. Commission	Under Construction
23	Uniport Multipurpose Hall	University of Port-Harcourt	Constructed
24	Union Bank	Union Bank.	Constructed
25	RA Type 3 Apartment Block Building Phase 1 Project For Nigerian Liquified Natural Gas Company, Bonny.	Alcon Nig. Ltd. For NLNG	Constructed
26	Land Reclamation and Shore Protection Works at Ogoloma town, Okrika LGA.	Niger Delta Dev. Commission	Under Construction
	BENUE/NASSARAWA		
27	Design of Benue linking Loko-Oweta between Benue and Nassarawa States.	Federal Ministry of Works	Design Completed
	YENAGOA		
28	Central Bank	Central Bank of Nigeria.	Constructed
29	Bayelsa Parastatal Tower	Bayelsa State Govt.	Design only

employees, contractors and visitors and other stakeholders. That said, every individual has a duty within the legislations to take care for their own health and safety and take due consideration for the health and safety of others. Compliance with all statutory obligations is a minimum standard. This Policy aims to go beyond this but will only work if there is a total commitment to health and safety by all concerned. The ultimate responsibility for health and safety within the company rests with the management.

A management structure which gives effect to the implementation of the company's health and safety policy is available. The company recognizes that failures in health and safety management have the potential to damage the human, professional and financial resources of the company.

Control of risk is a management responsibility inseparable from other aspects of professional management. To assist in the task of identifying and controlling risk, the company will appoint persons 'competent to provide advice' in accordance with the objectives of the company.

Each line responsible management must ensure as far as is reasonably practicable that everyone who may be affected by the business of the company is aware of the health and safety arrangements and has adequate information, equipment,

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instruction, training and supervision to enable hazards and risks to health to be avoided. The company is committed to ensuring that risk assessments are carried out as required by the legislations and other regulations where the need for risk assessment is defined.

Construction materials at site

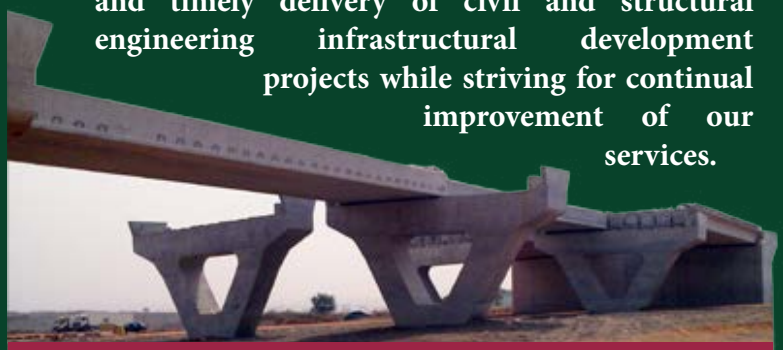
All Heads of Unit, Assistant Heads of Unit and other employees in supervisory roles must be familiar with the company's health and safety policy and recognize that they have responsibility for the health and safety of those whom they supervise. This affirms the company's view that achieving good health and safety standards is an essential part of good management and supervision.

In practice this means leading by example, promoting good working practices, ensuring that all equipment is maintained in safe condition, ensuring that instructions are in place and being followed, reporting accidents/incidents and investigating the causes of accidents in order to identify and implement remedial measures.

Construction equipment at site

OUR QUALITY POLICY STATEMENT

ETTEH ARO & PARTNERS is committed to provide full satisfaction to our clients and other interested parties with respect to quality, reliability and timely delivery of civil and structural engineering infrastructural development projects while striving for continual improvement of our services.



Construction in progress

Consequently, the company carries out internal assessments and reviews of existing methods, procedures and technology, and updates them regularly to ensure consistent quality standards in accordance with ISO 9001:2015 Quality Management System Requirements.

In order to achieve and maintain the EAP Quality policy, we are committed to making a difference by:

- **Meeting clients specific requirements for quality and time**
- **Providing best value engineering services to our clients**

Road project

Construction in progress

Construction in progress

- Realizing quality objectives established for infrastructure development projects
- Pursuing continual improvement
- Commitment to satisfy applicable requirements

These objectives are best achieved through company-wide communication and measurable by the level of conformance to the established and documented EAP ISO 9001:2015 Quality Management System.

It is therefore my directive that all members of the company shall henceforth diligently implement the EAP Quality policy.

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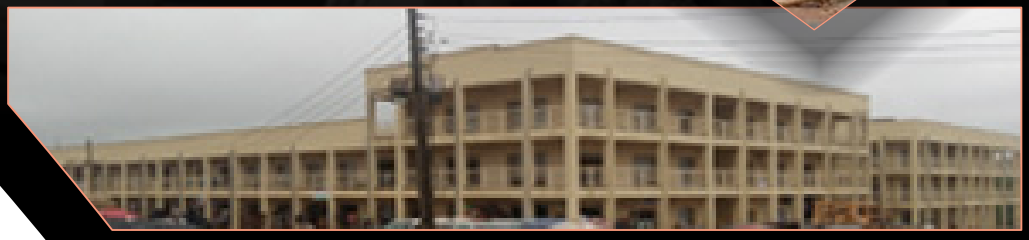

INFRAPLUS ENGINEERING

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FIDIC AFRICA INFRASTRUCTURE CONFERENCE

15TH – 17TH MAY 2022

L-R: *Chairman, Local Organising Committee – FIDIC Africa 2022/ ACEN Past President, Engr. Charles 'Yele Akindayomi, FNSE; Legal Officer, China Henan International Corporation Group Co. Ltd, Ms. Yun Wei; President - FIDIC Africa, Engr. Kabelo Motswagole, Pr. Eng; Representative of Managing Director - Lagos Metropolitan Area Transport Authority (LAMATA)/Guest Speaker, Engr. (Mrs.) Abimbola Akinajo FNSE; ACEN President, Engr. F. Ajibade Oke, FNSE and Session Facilitator/ CEO – Samabot and Associates Ltd, Engr. Sam Otenaike, FNSE.*

Director, Integrated City Planning, Arup/Arup Leader for India, Middle East and Africa/Keynote Speaker, Mrs. Sowmya Parthasarathy giving a keynote address at the conference.

Chief Executive Officer/MD - FIDIC, Dr. Nelson Ogunshakin FICE, OBE (l) during a courtesy visit to the office of the Executive Governor of Lagos State, Mr. Governor, Babajide Olusola Sanwo-Olu (r).

L – R: *Chairman, Local Organising Committee – FIDIC Africa 2022/ ACEN Past President, Engr. Charles 'Yele Akindayomi, FNSE; Chairman, Lagos Chamber of Commerce International Arbitration Centre (LACIAC)/Guest Speaker, Mrs. Abimbola Akeredolu, SAN, FCIArb; Director & Head, Infrastructure and Major Projects Advisory – KPMG Nigeria/Guest Speaker, Engr. Vince Onyejeli, MCIHT; Session Facilitator/ Past President – ACEN, Engr. K. A. Adeola, FNSE, FAEng, President - FIDIC Africa, Engr. Kabelo Motswagole, Pr. Eng; Director, MDA Consulting (Pty) Ltd/Guest Speaker, Engr. Ian Massey; Director & Global Head Administration, Afreximbank/ Guest Speaker, Dr. Robert L. Tomusange and ACEN President, Engr. F. Ajibade Oke, FNSE.*

President, ACEN Future Leaders, Engr. Olayinka Olanipekun (Front row, 5th from the left) and some of the FIDIC Future Leaders at the Conference.

President - FIDIC Africa, Engr. Kabelo Motswagole, Pr. Eng giving his welcome address at the conference.

L – R: *Immediate Past President - FIDIC Africa, Engr. James N. Mwangi, CE. FIEK.; FIDIC CEO/MD, Dr. Nelson Ogunshakin FICE, OBE, Special Adviser to the Governor on Works & Infrastructure, Lagos State, Mrs. Aramide Adeyoye FNIStructE; Chairman, Local Organising Committee – FIDIC Africa 2022 and ACEN Past President, Engr. Charles 'Yele Akindayomi, FNSE; Immediate Past President – ACEN and Member, FIDIC Africa Executive Committee, Engr. George C. Okoroma, FNSE, JP and President/CEO, Crusteam Group (ACEN Member firm), Engr. Barry Esimone, FNSE.*

1ST ACEN BUSINESS EVENING 16TH JUNE 2022

R - L: *The Guest Speaker at the event, Engr. Muhammad Ali Zarma MNSE, MNICE receiving an appreciation plaque from the ACEN President, Engr. F. Ajibade Oke, FNSE who is flanked to the left by the ACEN Vice President, Engr. Kam-Selem A. Bukar, FNSE, FNICE, and the ACEN Zone 4 Coordinator, Engr. M. B. Shettimah, MNSE.*

ACEN President, Engr. F. Ajibade Oke, FNSE(2nd left) flanked on the right by the ACEN Vice President, Engr. Kam-Selem A. Bukar, FNSE, FNICE, and the ACEN Managing Director, Engr. Kalejaiye Sunday, MNSE (left).

Cross-section of delegates at the event.

EGM 2022 21ST JULY 2022

ACEN President, Engr. F. Ajibade Oke, FNSE giving a welcome speech at the 2022 Extra-ordinary General Meeting in Port-Harcourt.

Cross-section of delegates at the event.

ACEN Managing Director, Engr. Kalejaiye Sunday, MNSE.

2ND ACEN BUSINESS EVENING 31ST AUGUST 2022

L - R: *ACEN Past President, Engr. K.A. Adeola, FNSE, FAEng giving a presentation as the Guest Speaker at the event; ACEN Managing Director, Engr. Kalejaiye Sunday, MNSE and ACEN President, Engr. F. Ajibade Oke, FNSE.*

A cross-section of physical participants at the event.

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT FOR HIGHWAYS

BY ENGR. IDOWU ADERIBIGBE

1.0 INTRODUCTION

1.1 WHAT IS HIGHWAY ENVIRONMENT?

'Environment' according to Highway Manual Part 1: Design, Volume VII, Environmental Management, is the surroundings (biophysical and social) in which humans exist and that are made up of:

- The land, water and atmosphere of the earth
- Micro-organisms, plant and animal life
- Any part or combination of (i) and (ii) including the interrelationships among them
- The physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and wellbeing.

According to Wikipedia, a highway is any public or private road or other public way on land. It is used for major roads, but also includes other public roads and public tracks. Highway environment can be said to imply the surroundings/corridors in which humans exist and that are made up of land, water, atmosphere, including the micro-organisms, plants, animal life and their interdependencies, as well as the physical, chemical, aesthetic and cultural properties as it affects human health and wellbeing.

2.0 DEFINITIONS AND OBJECTIVES OF ESIA ON HIGHWAY PROJECT

Environmental and Social Impact Assessment (ESIA) is defined as an activity designed to identify the impact on the bio-geophysical environment on man and his well-being arising from legislative proposals, projects, policies, operational procedures and to interpret and communicate information to stakeholders pertaining to the assessment. Alternatively, ESIA is a systematic process of identifying future consequences of a current or proposed action.

According to the World Bank, Environmental and Social Framework (2017), Environmental and social impact assessment (ESIA) is an instrument to identify and assess the potential environmental and social impacts of a proposed project, evaluate alternatives and design appropriate mitigation, management and monitoring measures.

Engr. Idowu Aderibigbe, *MNSE (Principal Partner, Joint Konsult)*

The objectives of ESIA are to:

i. Identify, predict and evaluate the economic, environmental and social impact of development activities
ii. Provide information on the environmental consequences for decision making
iii. Promote environmentally sound and sustainable development through the identification of appropriate alternatives and mitigation measures

3.0 APPROACH & METHODOLOGY OF ESIA IN A HIGHWAY PROJECT

Whenever a new development project is planned which is likely to affect environmental quality, it is necessary to carry out ESIA.

a. The first step in ESIA method is to determine whether the project under consideration follows the jurisdiction of the relevant Acts and Regulations and if so, whether it is likely to create a significant environmental disruption.
b. If so, an ESIA is undertaken and the Environmental Impact Statement (EIS) is prepared.
c. In many countries, including Nigeria, EIS is open to public scrutiny and is reviewed at public hearings.
d. Finally, a political decision is taken.

The development project may be:

- accepted or
- accepted with amendments or,
- an alternative proposal is accepted or,
- rejected

The Nigerian EIA Sectoral Guidelines for Infrastructure Projects of 1995 describe the following steps which need to be undertaken for roads and highway development projects prior to construction activities:

- Project justification
- Project description
- Description of the receiving environment
- Public consultations
- Description of the associated and potential environmental impacts (biophysical and social), including site selection during the construction, operation and maintenance phases of the project
- Description of the mitigation measures for potential impacts identified
- Environmental Management Plan (EMP) for compliance monitoring of the mitigation measures identified for the project
- Remediation plans after decommissioning of the project including a description of both the negative and positive impacts which will result during the closure of the highways

The ESIA process as applied in Nigeria is as presented in Fig. 1 below.

4.0 GUIDING PRINCIPLES

The entire process of ESIA is governed by the following principles:

i. Participation: An appropriate and timely access to the process for all interested parties
ii. Transparency: All assessment decisions and their basis should be open and accessible
iii. Certainty: The process and timing of the assessment should be agreed by all participants in advance
iv. Accountability: The decision makers of all parties are responsible for their action and decisions under the assessment process
v. Credibility: Assessment is undertaken with professionalism and objectivity
vi. Cost effectiveness: The assessment process and its outcomes will ensure environmental protection at the least cost to the society
vii. Flexibility: The assessment process should be able to deal efficiently with any proposal and decision-making situation
viii. Practicality: The information and outputs provided by the assessment process are readily usable in decision making and planning

Fig. 1: *EIA Process flowchart (Source: Federal Ministry of Environment Website)*

- In-house review
- Public review (21 days display)
- Panel review

The proponent starts preparatory works on the project site and prepares the final EIA report.

Compliance of mitigation measures is checked on the project site.

EA Dept. approves the EIA Report and issues the EIS and the certificate.

5.0 ESIA PROCESS IN SEQUENCE OF APPLICATION

a) Stakeholder's Involvement: Stakeholders' involvement occurs in various stages of EIA to ensure quality, efficiency and effectiveness.

b) Project Screening and Scoping:

- Determine necessity for EIA requirement
- Describe various screening criteria (See Table 1)

- Scoping determines coverage or scope of EIA

c) Project Design and Construction:

- Type of project under consideration
- Physical dimensions of the area are considered
- Consideration on optical use of resources
- Confirmation of irretrievable commitment of land
- Identifying whether the project is a critical phase of a larger development
- Ascertaining whether there will be serious environmental disruptions during construction
- Finding out the long-term plans of the proponent

d) Project Operation: The relevant questions to be answered in respect of operation are:

- What provisions have been made to check the safety equipment regularly?
- How will the hazardous waste products be handled?
- What are the contingency plans developed to cope up with the possible accidents?
- What provisions have been made for training the employees for environmental protection?
- What plans have been made for environmental monitoring?

e) Site Characteristics: Answers are sought for the following pertaining to the project site:

- Is the site susceptible to floods, earth quakes and other natural disasters?
- Else, is the terrain creating problems in predicting ground water characteristics and air pollution etc.?
- Is the local environment conductive for the success of the project?
- How many people are likely to be displaced because of the project?
- What are the main attributes (e.g., protein content, calorie content, weed or pest status, carnivorousness, rarity of species, etc.) of the local fauna and flora?
- Will the project interfere with the movements of fish population and important migratory animals?
- Will historic sites be endangered because of the project?

f) Possible Environmental Impacts: The relevant questions in the exercise are:

RISK CATEGORY	SCREENING CRITERIA
High	The resource/receptor would likely experience a large magnitude impact that would endure for a long time, extend over a large area, exceed national/international standards, endangers public health and safety, threatens a species or habitat of national or international significance, and/or exceeds a community's resilience and ability to adapt to change. The Project may have difficulty in complying with the applicable ESF requirement, and significant mitigation would likely be required.
Substantial	The resource/receptor would experience a clearly evident change from baseline conditions and would approach but not exceed applicable standards. The Project would comply with the applicable ESF requirement, but mitigation would be required.
Moderate	The resource/receptor would experience a noticeable effect, but the magnitude of the impact is sufficiently small (with or without mitigation) that the overall effect would remain well within applicable standards. The Project would comply with the applicable ESF requirement, but mitigation may be required.
Low	The resource/receptor will either not be affected or the likely effect would be imperceptible or indistinguishable from natural background variation. The Project would comply with the applicable ESF requirement and mitigation would typically not be required.

Table 1: *Risk Screening Criteria*

- What are the possible short-term and long-term environmental impacts from the project during construction and after construction?
- Who would be affected because of these impacts?

g) Mitigation Measures:

- Design a system to avoid, reduce and minimize adverse impacts.
- Enhance beneficial outcomes.

h) Monitoring and Auditing Measures:

- Identify impacts that require monitoring and auditing.

i) Socio-Economic Factors: These factors are addressed through seeking answers to the following:

- Who are the expected gainers and losers by the project?
- Where are the expected trade-offs?
- Will the project interfere (blend, increase or reduce) with the existing inequalities between occupational, ethnic and age groups?
- Will it affect the patterns of local/regional/national culture?

j) Availability of Information and Resources: In the ESIA exercise, there will be need to know:

- Whether local and outside experts are available to consult specific impacts of the project
- Whether the relevant guidelines, technical

information and other publications are available to identify the possible impacts of similar projects
- Whether relevant environmental standards, by-laws etc. are considered
- Whether the sources of relevant environmental data are identified and whether they are accessible
- Whether the views of the specialist groups and general public regarding the project have been considered
- Whether the competent technical manpower is available to handle the project

k) ESIA Report and Review: Complete information in ESIA report should include non-technical summary, methodologies used, results, interpretation and conclusions. A review assesses adequacy of issues and facilitates the decision making process.

l) Decision Making: Based on the ESIA report, the project may be accepted, accepted with alterations or rejected.

6.0 ENVIRONMENTAL PRINCIPLES, POLICIES AND LEGISLATIONS

All road projects can have potentially significant effects on the environment. As a result, professionals must plan, design, construct and operate the completed road project in line with relevant environmental laws as it affects the project at each phase.

6.1 LAWS AND CONVENTIONS

These include:

a) Nigeria National Environmental Policy 1998 which commits to sustainable development based on the proper management of the environment
b) Environmental Impact Assessment (EIA) Act No 86 of 1992 which makes EIA a mandatory tool for all new public and private projects in Nigeria
c) Land Use Act No 202 of 1990
d) Harmful Waste Act No 42 of 1988
e) Water Resources Decree No 101 of 1993
f) National Guideline and Standards for Environmental Pollution Control 1991
g) National Transport Policy of 1993 as amended in 2010
h) Master Plan for Integrated Transport Infrastructure of 2002
i) Draft National Policy of 2003
j) Federal Road Maintenance Agency Bill of 2001
k) Federal Highway Act CAP 135 (revised 1990)
l) Draft Federal Highway Bill 2001
m) Resettlement Policy Framework, April 2006
n) Vienna Convention for Ozone Layer Protection
o) Convention on the Conservation of Migratory
p) Convention on Biological Diversity
q) World Heritage Convention
r) Mineral and Mining Act No 20 of 2007
s) Minerals and Mining Regulations 2011
t) The African Convention 1968
u) The Basel Convention 1989
v) Kyoto Protocol of 1995

> *"All road projects can have potentially significant effects on the environment."*

6.2 THE WORLD BANK ESS

The World Bank Environment and Social Framework and Standards are described briefly below:

All projects funded by World Bank Funded Investment Project Financing (IPF) are required to follow the Environmental and Social Framework (ESF) consisting of ten (10) Environmental and Social Standards (ESS). These ESSs set out their requirements for the borrowers relating to the identification and assessment of environmental and social risks and impacts associated with any project. The ESSs support the borrowers in achieving good international practice relating to environmental and social sustainability, assist them in fulfilling their national and international environmental and social obligations, enhance transparency and accountability and ensure sustainable development outcome through ongoing stakeholder engagement.

These standards are:

i. Environmental and Social Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
ii. Environmental and Social Standard 2: Labor and Working Conditions
iii. Environmental and Social Standard 3: Resource Efficiency and Pollution Prevention and Management
iv. Environmental and Social Standard 4: Community Health and Safety
v. Environmental and Social Standard 5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement
vi. Environmental and Social Standard 6:

Biodiversity Conservation and Sustainable Management of Living Natural Resources

vii. Environmental and Social Standard 7: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities

viii. Environmental and Social Standard 8: Cultural Heritage;

ix. Environmental and Social Standard 9: Financial Intermediaries

x. Environmental and Social Standard 10: Stakeholder Engagement and Information Disclosure

7.0 RISK SCREENING

This is an important aspect of ESIA. Risk screening criteria are always adopted to arrive at the risk assessment for the project. Table 1 provides the risk screening criteria based on the World Bank Environmental and Social Framework (ESF).

Risk Category Screening Criteria

High: The resource/receptor would likely experience a large magnitude impact that would endure for a long time, extend over a large area, exceed national/international standards, endangers public health and safety, threatens a species or habitat of national or international significance, and/or exceeds a community's resilience and ability to adapt to change. The Project may have difficulty in complying with the applicable ESF requirement, and significant mitigation would likely be required.

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Low: The resource/receptor will either not be affected or the likely effect would be imperceptible or indistinguishable from natural background variation. The Project would comply with the applicable ESF requirement and mitigation would typically not be required.

> *"This is a comprehensive document that directs effective and responsible implementation..."*

8.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

This is a comprehensive document that directs effective and responsible implementation and management of environmental and social impacts mitigation and enhancement measures during the construction, operation and closure phases of a proposed project.

The purpose of the ESMP is to define and reach the requirements of the project sponsors and local environmental regulations regarding the following:

- Beneficial and adverse impacts
- Mitigation and enhancement programs
- Monitoring programs
- Consultations
- Complementary initiatives
- Responsibilities and institutional arrangements
- Estimated costs
- Implementation schedules and reporting

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"THE CONSULTING ENGINEER" PERSONALITY

ENGR. ADEKUNLE OLUMUYIWA MOKUOLU FNSE

(CHAIRMAN, MOKS ENGINEERING CONSULTANTS LTD)

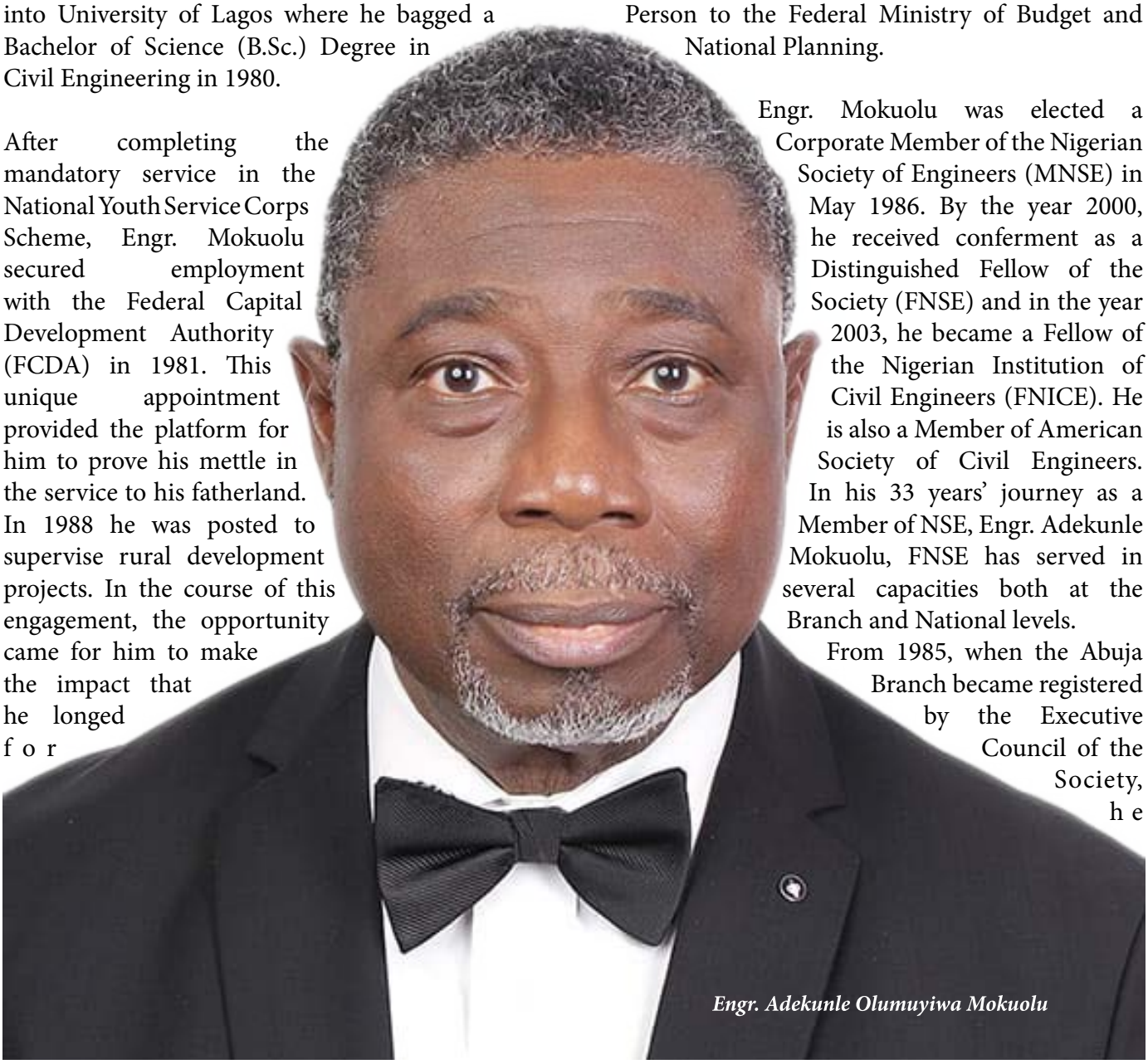
Engr. Adekunle Olumuyiwa Mokuolu was born on June 1, 1954 in Lagos, Nigeria. Born to well-educated parents, Engr. Mokuolu had the opportunity of having good education early in life. He got his First School Leaving Certificate from the Ibadan City Council Primary School, Inalende, Ibadan in 1966. He attended the Baptist Boys' High School, Abeokuta and the Eko Boys' High School, Mushin, Lagos for his secondary education. Afterwards, he proceeded to the Federal School of Arts and Sciences, Lagos for the Higher School Certificate. Thereafter, he gained admission into University of Lagos where he bagged a Bachelor of Science (B.Sc.) Degree in Civil Engineering in 1980.

After completing the mandatory service in the National Youth Service Corps Scheme, Engr. Mokuolu secured employment with the Federal Capital Development Authority (FCDA) in 1981. This unique appointment provided the platform for him to prove his mettle in the service to his fatherland. In 1988 he was posted to supervise rural development projects. In the course of this engagement, the opportunity came for him to make the impact that he longed for as a student Engineer on Training in the UK. He served in various other capacities in the FCDA until he voluntarily retired as a Deputy Director in 2009. He currently seats as the Chairman of the Board of MOKS Engineering Consultants Limited, an engineering consortium that he set up.

At various times, Engr. Mokuolu had delivered papers on the sustainable infrastructure development of Nigeria. He has been a Member of Infrastructure Policy Commission of the Nigeria Economic Summit Group from 2009 till date and a Resource Person to the Federal Ministry of Budget and National Planning.

Engr. Mokuolu was elected a Corporate Member of the Nigerian Society of Engineers (MNSE) in May 1986. By the year 2000, he received conferment as a Distinguished Fellow of the Society (FNSE) and in the year 2003, he became a Fellow of the Nigerian Institution of Civil Engineers (FNICE). He is also a Member of American Society of Civil Engineers. In his 33 years' journey as a Member of NSE, Engr. Adekunle Mokuolu, FNSE has served in several capacities both at the Branch and National levels.

From 1985, when the Abuja Branch became registered by the Executive Council of the Society, he



Engr. Adekunle Olumuyiwa Mokuolu

served at various times as Social Secretary, Publicity Secretary, Assistant Secretary, General Secretary, Vice Chairman, Chairman (a position held from 1995 - 2001) and Ex-Officio Member (from 2002 – 2003)

Engr. Adekunle O. Mokuolu

At the national level of NSE, Engr. Mokuolu has also served in both elective and non-elective positions as Assistant Publicity Secretary (1990 – 1992), Assistant Secretary General (1993), Un-Officio Member (1994 – 1995), Member of Executive Council (1990 - 2001 & 2008 – 2019), Chairman Editorial Board, NSE Newsletter (1990 – 1992), Editor of 'The Nigerian Engineer' magazine (2009), Examiner (Civil) NSE Professional Interview, Abuja Centre (1995 – 2009),

He has been appointed Member of the following NSE Committees and Boards at various times: - Revision of 'THIRTY YEARS AHEAD' long-range plan; Conference Planning; Publicity; Membership; Constitution Review; Welfare; 1st Technology Summit; Investment and Properties - 2006; Finance and General Purpose - 2006.

He became Vice President (Personnel and General Administration) in 2008 and Vice President (Professional Development) in 2009 and 2010.

As reward for hard work and dedication to the Society, he has received the following Awards at different times:
Presidential Merit Award – 1992
Presidential Merit Award – 1993
Distinguished Service Award, Abuja Branch – 2003
Individual Service Award, Abuja Branch – 2004
Ambassadorial Award, Abuja Branch - 2009.
Professional Merit Award of the Nigerian Institution of Civil Engineers (NICE) - 2009.
On December 31, 2019, he ended his tenure as the 31st President of the Nigerian Society of Engineers.

He is currently a Law Student at the Faculty of Law, Baze University, Abuja.

Engr. Adekunle Mokuolu was considered worthy by the Baptist Boys' High School Old Boys Association (BBHSOBA) to receive the Merit Award of the OBA in 2012.

Engr. Adekunle Mokuolu is married to his beautiful and amiable wife, Mrs. Oluyemisi Mokuolu who is an educationist. Both are Deacon and Deaconess of First Baptist Church, Garki, Abuja and are also members of the Gideons International – an organization fully committed to making the love of God in Jesus Christ known to others through the distribution of Bibles on traffic lanes of life. They are blessed with children who already own spaces globally in their various professions.

Engr. Adekunle Mokuolu's hobbies are reading, swimming, development of Baptist Boys' High School, Abeokuta and making others happy.

KEY POSITIONS OF RESPONSIBILITY

- President of the Nigerian Society of Engineers. (Jan. 2018 to Dec. 2019)
- Member of Governing Board, National Agency for Science and Engineering Infrastructure (NASENI). (2018 to 2019)
- Member of Vision 20:2020 Central Working Group for Implementation Strategies for Physical Infrastructure. (Nov. 2009 to Date).
- Member of Ministerial Committee on Strategies for Implementation of Executive Order 5. (June 2018 – Dec. 2019)
- Member of the Nigerian Economic Summit Group (NESG) Infrastructure Policy Commission. (Jan. 2009 to Date).
- Founder/President of Engineering Infrastructure Development Initiative (EIDI) – a Non-Governmental Organization with Corporate Affairs Commission Reg. No. 29531. (Sept. 2008 to date) and certified by EFCC.
- Chairman, Ogun State Committee on Review of Contracts/Projects Awarded Between 2009 – 2019 – (July 2019 to Oct. 2020)
- Coordinator and Member of the Technical Working Group on Infrastructure for Nigeria Development Agenda for 2020 and Medium Plan 2021-2025. (June 2020 to Date)
- Ordained Deacon of First Baptist Church, Garki, Abuja. (2002)
- Chairman, Technical Committee for Development of Nigerian Baptist Convention (NBC) Kubwa Land. (June 2019 to April 2022)

A WORD FOR YOUNG ENGINEERS

BY ENGR. ADEKUNLE OLUMUYIWA MOKUOLU

Engr. Adekunle O. Mokuolu, *FNSE*
(Chairman, Moks Engineering Consultants Ltd)

I feel highly privileged to share words of counsel with young engineers using this engineering media platform. As an engineer who has been in professional practice for several years coupled with my privilege as a past President of the Nigerian Society of Engineers, I can say with a sense of humility that there is a rich repertoire of experience to share with the young ones in the profession.

Let me begin by expatiating on the words, "Young Engineers". A young engineer, in this context, is one who has completed a program of studies in Engineering in an accredited institution of higher learning. He may be unemployed or in employment. There are vital issues of life which the young engineer should be conscious about. I like to point them out as follows:

1. **TRAINABILITY:** A trainable young engineer is the one who would readily acquire knowledge to improve his capability to deliver sound engineering services. A young engineer who is not trainable would normally feel he knows it all. Of course, he is likely to falter, make mistakes and may even ruin his career. Knowledge is like a garden. If you do not cultivate, you cannot harvest it. Be trainable and acquire knowledge when you are young so you can reap the benefits as you progress to the later stages of your career.
2. **MARKETABILITY:** The marketability of a young engineer is enhanced by knowledge. Knowledge, when well applied, translates to competence. Competence should not be hidden. Your competence should be known to the public, particularly, the relevant segment of the public. It was common in the past for engineering consultants to presume that clients will look for them because of their expert knowledge and consciously refused to use the media to make themselves known to the public. That time has gone. The competence of engineers should be advertised in appropriate media platforms to draw the attention of potential clients to use their services. Advertising is an important component of business management and engineers should not be left out.
3. **DIGITAL SKILLS ACQUISITION:** The 21st Century skills set must include digital skills. The quest to transform Nigeria's economy into a digital one is gaining momentum. This is spearheaded by the National Information Technology Development Agency on behalf of the Federal Government. This is also the trend in other climes. A report by Accenture in 2021 in United Kingdom lends credence to the importance of digital skills. The report showed that the demand for artificial intelligence, cloud and robotics skills is soaring. Another study by the World Bank and International Finance Corporation entitled "Demand for Digital Skills in sub-Saharan Africa, WB, IFC, 2021" showed that of all the 5 countries surveyed (Cote d'Ivoire, Kenya, Mozambique, Nigeria and Rwanda), 57 million jobs would require digital skills by 2030. This underscores the need for young engineers to invest in digital skills acquisition. Digital skills enhance engineering service delivery considerably.
4. **BUSINESS SKILLS ACQUISITION:** The business side of professional practice is a good complement to engineering knowledge. There is a disadvantage in engineering practice when you understand only Technical Tender and have no understanding of Commercial Tender. As a young engineer, you should look for opportunities to get training in Financial Management, Marketing Management, Human Resources Management and Leadership to improve your versatility.
5. **PROFESSIONAL REGISTRATION:** As a young engineer, your tutelage should be in relevant engineering practice with a build-up of experience for a hitch-free registration with the Council for Regulation of Engineering in Nigeria (COREN) and the Nigerian Society of Engineers (NSE). After registration with COREN, you are recognized as a professional engineer.
6. **INTEGRITY:** It is important that you maintain integrity in your practice and career. This is what will keep you as a dependable engineering practitioner. Excellence and quality delivery in your engineering practice should not be compromised. By your education in Engineering, you have what it takes to contribute to infrastructural development in the country in areas such as highways, bridges, railways, dams, commercial & residential buildings, power, oil & gas facilities, chemical process plants, agro-processing factories, etc. Be sure you add value.

In conclusion, leaning on the adage that says "A glorious past is the work of a glorious man", aim to make your engineering practice and career glorious.

We guarantee quality engineering services

Our firm is richly endowed with a superb combination of world class professional expertise and integrity which reliably guarantee quality delivery of projects to the delight of our growing number of clients.

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COMPARATIVE ANALYIS OF CONCRETE AND ASPHALT ROADS

BY ENGR. LANRE SAGAYA JR.

Engr. Lanre Sagaya Jr. *MNSE*
(Director, Yolas Consultants Ltd)

1.0 INTRODUCTION

Road transport is vital to the social and economic development of any country and remains, by far, the most important mode of transport in Nigeria, both with regards to passengers and goods. Fig.1 shows a Nigeria map and road network. Asphalt has traditionally been the first material of choice for roadway pavements in Nigeria, with the majority of the paved roads in the Nigerian roadway network having the ubiquitous black top. Concrete roads are popular worldwide, with some states in the USA e.g. Texas; having the majority of its roads constructed with concrete. Public Private Partnership initiatives that have come more into the fore, arising from dwindling Government funding of infrastructure globally and specifically Nigeria's Presidential Executive Order No. 7 of

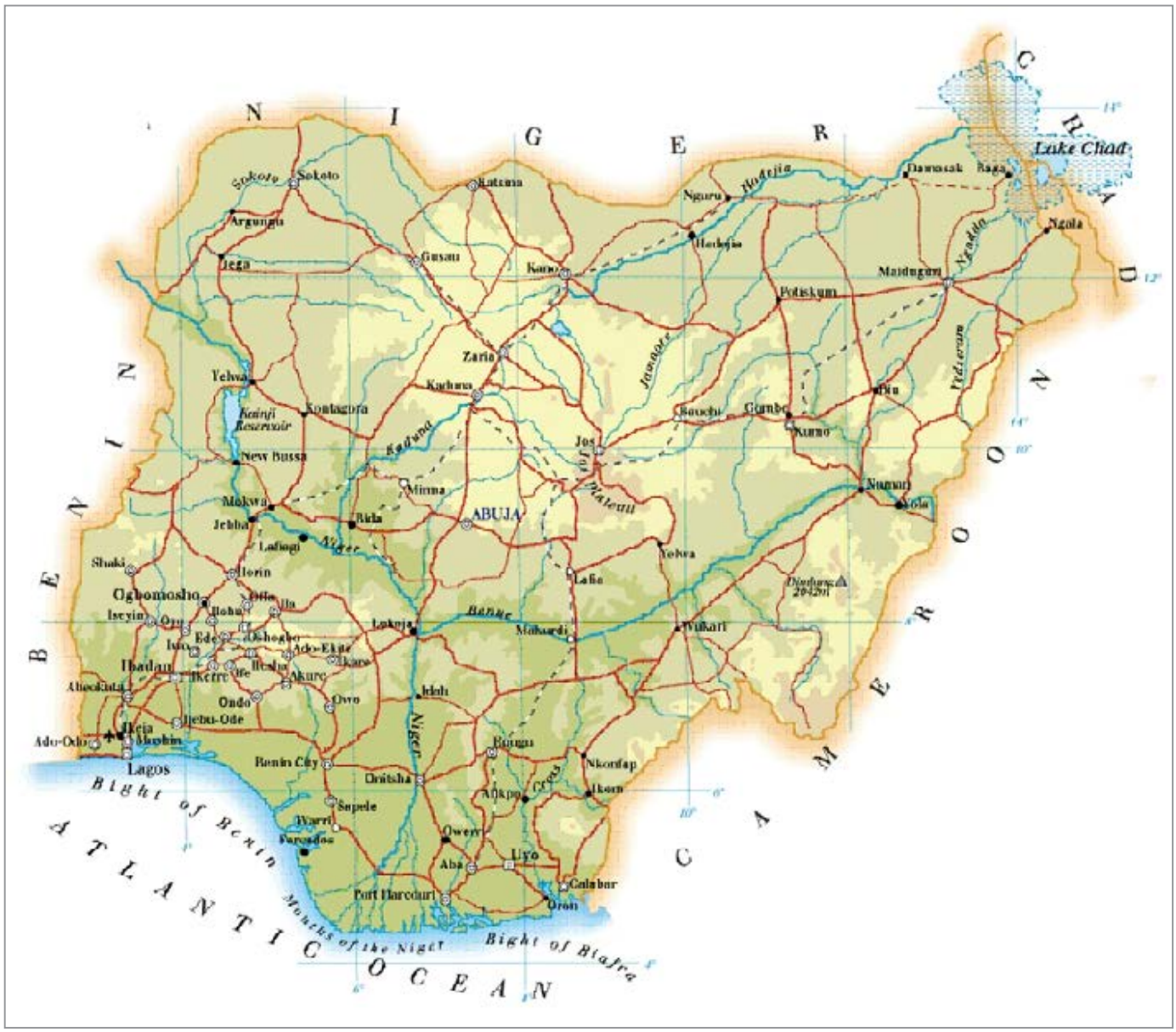

Fig. 1: *Nigeria map and road network*

2019: Road Infrastructure Development and Refurbishment Investment Tax Credit Scheme (RIDRITCS), have led to a rethink of asphalt having a monopoly in road pavement construction.

"Participating investors will use tax credits to reduce corporate taxes payable to government until they recoup the value of their investments in roads and bridges."

The Minister of Finance, Zainab Ahmed said, "The Executive Order #7 of 2019, entitled 'Road Infrastructure Development and Refurbishment Investment Tax Credit Scheme', is the outcome of efforts to think outside of the box and deploy new techniques to develop critical roads infrastructure in the country.

Participating investors will use tax credits to reduce corporate taxes payable to government until they recoup the value of their investments in roads and bridges. Essentially, this scheme will utilise tax expenditures, refundable by way of tax credits, to finance the construction of critical roads infrastructure through a Public Private Partnership mechanism.

In this pilot phase, the following six private sector companies have chosen to participate in the Scheme:

a) Dangote Industries Limited;
b) Lafarge Africa Plc;
c) Unilever Nigeria Plc;
d) Flour Mills of Nigeria Plc;
e) Nigeria LNG Limited; and
f) China Road and Bridge Corporation Nigeria Limited."

Dangote Industries and Lafarge Africa have been spending their own funds to construct roads in the country since RIDRITCS's inception and more private companies have signed up to the scheme.

What they are using are concrete pavements which have increasingly been gaining popularity. This is the participating company's preferred construction material. The recently reconstructed Apapa – Oshodi - Oworonsoki Expressway in Lagos by Dangote Group is a strategic highway constructed as a Continuously Reinforced Concrete Pavement (CRCP). This is a prime example.

However, it is not clear-cut which roadway pavement is better, asphalt or concrete, it is dependent on several factors as will be further explained.

2.0 CONCRETE PAVEMENT ADVANTAGES

One of the benefits of concrete is that it is a 'greener' material than asphalt i.e. the production of concrete, that is, mixing of cement with aggregates and water (plus additives as necessary) produces much less carbon emissions than the melting of bitumen that is needed for the production of asphalt.

Concrete also has advantages over asphalt in terms of short to medium term performance of a roadway pavement. Being that it is a more rigid material, it is less prone to the early defects of flexible asphalt pavements such as rutting and pavement shoving. Anecdotally, it is said that concrete is better suited to high truck volumes. However, the long-term performance of concrete pavement has some disadvantages to be discussed later.

Another advantage is that quarries and cement manufacturers are readily available in the country whereas most of Nigeria's asphalt is imported. This is, in itself, a paradox because the country has high bitumen deposits.

Minister of Mines and Steel Development, Dr. Kayode Fayemi, had lamented that about 80 per cent of asphaltic materials used for road construction in the country are still being imported despite the vast bitumen deposit……Nigeria is reputed for having the second largest deposits of bitumen in the world, spanning approximately 120 kilometres covering Ogun, Ondo, Lagos and Edo states.

3.0 CONCRETE PAVEMENT DISADVANTAGES

In the long-term, concrete road is at a disadvantage compared with asphalt because maintenance interventions such as patching are difficult. Depending on the type of concrete pavement

(Jointed Concrete Pavement, JCP or Continuously Reinforced Concrete Pavement, CRCP), entire slabs may have to be replaced to fix a small section of road failure. This is obviously very costly.

The drive on concrete pavements is also not as smooth as that of asphalt because the texture of concrete makes for a slightly bumpy and noisy ride. The cost of laying concrete pavements and the maintenance costs are both higher than those of asphalt pavements.

"It seems simplistic to say concrete roads are better than asphalt pavements or vice versa. Consulting engineers are to advise clients and PPP project sponsors to consider..."

4.0 ASPHALT PAVEMENT ADVANTAGES

The biggest benefit of asphalt is that it has a price advantage over concrete, both in terms of initial construction expenses and maintenance costs.

Asphalt also allows for a smoother and quieter ride than concrete paved roads, the blacktop's texture being a smoother surface. Also, asphalt being a flexible material, provides better vehicle skid resistance than concrete.

Asphalt roads have an advantage because repairs of asphalt roads are quicker and cheaper when compared with concrete roads.

5.0 ASPAHLT PAVEMENT DISADVANTAGES

Melting of bitumen and the production process at asphalt plants produce large carbon emissions and are, therefore, not environmentally friendly. This is a particular disadvantage in today's age of existential climate change challenges.

The quick maintenance interventions required, such as wearing course overlays, on asphalt roads are frequent. Though relatively inexpensive, this frequent maintenance will affect the quality of the road, especially if not properly supervised and monitored during construction activities.

Nigeria imports most of its bitumen for asphalt production and this contributes to the dwindling of foreign reserves. This is another disadvantage of asphalt roads over concrete roads in our country.

6.0 CONCLUSION

It seems simplistic to say concrete roads are better than asphalt pavements or vice versa. Consulting engineers are to advise clients and PPP project sponsors to consider:

i. The local context of the availability of cement and bitumen in the country. Also, the proximity of the road to a quarry or whether it is in a State with high bitumen deposits and the State Government's traction in developing the extraction industry.
ii. The long-term pavement performance of the pavement i.e. the initial cost of construction is not the only factor in making the decision. For example, an arterial or rural road may be better constructed in asphalt because of the lower truck volumes but take a highway in Kogi State with heavy traffic, for instance (say the Abuja - Lokoja Highway that has been identified for tolling by the Federal Government), it may be better to construct in concrete, with the high maintenance costs to be covered by the tolling funds.

In conclusion, there is no simple answer to the question of which is better, concrete or asphalt roads. It is important to consider the specific peculiarities of any road project. Ultimately, the two materials will remain the primary materials for road construction in the foreseeable future. This is subject to technological advances (the addition of stabilization additives) and environmentally friendly (recycled materials such as plastics) meant to achieve improvements.

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50TH ANNIVERSARY (1972 - 2022) MO&A
50 Years of Engineering Excellence

INTRODUCTION

Morgan Omonitan & Abe Ltd, popularly referred to as MO&A, clocked 50 years on July 3, 2022. Over these years, the firm has built a respectable reputation in engineering consultancy services through the execution of numerous landmark projects of impeccable quality standards. The firm has distinguished itself as one the foremost engineering consultancy firms operating in Nigeria with global expertise.

EARLY HISTORY AND MILESTONES

In April 1960, an enterprising British engineer called Eric Morgan came to Nigeria to work alongside a major construction company, Cappa & D'Alberto. The task was to build the Western House in Lagos and the Cocoa House in Ibadan (the tallest buildings in Africa at that time) which can now be appropriately described as two outstanding monuments of commerce.

Eric Morgan's fascination for Nigeria kept him here well after the completion of the two pioneering projects and he soon became the Chief Engineer for Group Consultants, an Engineering firm based in Lagos. It was through this engagement that Eric came across a British-trained Nigerian engineer, Gabriel Omonitan who had been recruited to come back to Nigeria to work on some projects being handled by Group Consultants.

It was during the course of their interactions on the projects that the two engineers shared similar professional ethics and values, leading them to establish Morgan Omonitan & Associates in 1972.

Morgan Omonitan & Associates commenced operations from a small office on Strachan Street, Lagos Island, and grew steadily from managing small engineering projects to bigger ones which included the University of Lagos Conference Centre in Yaba, Apex Paper Mill in Ijora, and the Nichemtex Textiles Factory in Ikorodu.

From then on, the firm's engineering excellence saw it managing even more successful projects in Northern Nigeria, leading to the acquisition of a structural engineering consultancy firm called P.J. Norton whose office automatically became MO&A's Kaduna office.

MO&A was appointed structural engineering consultant to Peugeot Automobile Nigeria (PAN), as well as other notable projects within the northern Nigeria Textile industry.

L – R: *Eric Morgan, Mrs. Omonitan, Mrs. Morgan and Gabriel Omonitan*

Following the succession planning and eventual retirement of MO&A's founding fathers, Messrs. Dapo Abe, Murray Ekong and Ayo Opasanya took over the baton of the firm's leadership and have done so, from 1988 to date, carrying on the rich legacy of engineering excellence, alongside a team of dynamic and industrious professionals who share MO&A's ethics and values. The Directors' pictures are shown below:

Engr. Dapo Abe

Engr. Murray Ekong

Engr. Ayo Opasanya

While staying true to the time-tested legacy of excellence, innovation drives the firm forward, as MO&A continues to grow and expand beyond Nigeria's frontiers to West Africa, with clear sights set on other parts of the African continent. In order to stay focused on delivering excellent engineering services to clients, MO&A is guided by its well-crafted vision, mission statements and core values.

MO&A'S VISION

To be the 'go-to' experts for creative and sustainable engineering project design and development solutions provider in Africa.

MO&A'S MISSION

To provide innovative and enduring engineering design and development solutions to the built-environment, through imaginative lateral thinking to meet client and end-user needs.

MO&A'S CORE VALUES

- Knowledge and best practice expertise in all aspects of engineering design and development and project management
- Integrity and high standards in our designs, business operations and conduct
- Responsiveness in how we meet the needs of our clients and stakeholders
- Innovation in our application of lateral approach techniques to engineering solutions
- Tenacity in our resolute quest to consistently find appropriate economic solutions
- Drive and passion in our delivery of quality design and development solutions

FOCUS AREAS OF COMPETENCE

MO&A offers highly professional engineering services in the following areas:

- Feasibility Studies
- Tender & Detailed Design
- Project Management
- Independent Design Checking
- Construction Supervision
- Construction Audit
- Value Engineering
- Condition Surveys, Structural Inspections and Monitoring
- Ground Investigation, Specifications and Interpretation
- Erection Engineering and Temporary Works Design
- Design Interface and Management

PROJECT SECTORS AND SOME EXECUTED PROJECTS

Projects executed by MO&A cut across different sectors in Nigeria and Ghana as enumerated below:

- Airports and Aviation-Related Developments
- Civil Engineering Infrastructural Developments
- Commercial and Corporate Office Developments
- Educational & Institutional Developments
- Health and Medical-Related Developments
- Hotel & Hospitality Sector Developments
- Industrial Sector Developments
- Multi-Unit Housing & Residential Sector Developments
- Project Management Services
- Retail & Recreational Sector Developments
- Specialty Projects Developments

Murtala Muhammed Airport Terminal 2 (MMA2)

EXECUTED PROJECTS CONT'D

Port-Harcourt - Warri Road Rehabilitation

Adinkra Towers Office Development, Accra, Ghana

Coca-Cola International HQ, Ikoyi, Lagos

International Diagnostics Centre, Abuja

Silver Valley Mall, Port-Harcourt (Proposed Retail Shopping Mall)

Novotel Hotel, Port-Harcourt

Heritage Place, Ikoyi, Lagos.

AWARDS

The distinctive performance of MO&A over the years has earned the firm numerous awards some of which are displayed

TESTIMONIES

Some MO&A's clients have greatly encouraged the firm through what they say about their competence. Some of these testimonies are placed here for the record.

i. Beverly Development & Realities Ltd

"Midway into construction, Morgan Omonitan & Abe Limited also took over the role of Project managers for the project. We are pleased to attest that under the leadership of Engr.. Dapo Abe, the firm discharged its dual mandate with a very commendable level of competence and professionalism. Having completed the project, we take pride in the exceptional project management leadership displayed by the firm in the birth of the best Mall in Nigeria in terms of ambience, quality of construction and functionality. In view of the above, we have no hesitation in recommending the firm of Morgan Omonitan & Abe Limited to any potential clients in Nigeria and abroad."

Mohammed Hayatu-Deen, Chairman

ii. Stanbic IBTC Bank Plc

"MO&A was the Consulting Structural Engineering Firm in charge of our head office annex building and our "One Walter Carrington" residential flats project. The firm provided an exceptionally professional service on both projects to our satisfaction. We are very impressed by their standard of service and are pleased to recommend them to you."

Atedo N. A. Peterside O O N
Managing Director
Stanbic IBTC Bank Plc

iii. Moorhouse Properties Limited

"MO&A is an epitome of excellence, character and quality. The firm has vast experience in designing structures that cannot be questioned locally or internationally. It approaches each project with the same degree of professionalism and interest. The firm has worked with us on many major & prestigious hotel & hospitality projects. Some of them are: "The Moorhouse Sofitel, The Moorhouse Sofitel Expansion project and The Novotel Port- Harcourt". The firm's most laudable character is the willingness to approach design work with gusto and an open mind in order to achieve the best, having the architect's intentions in mind. We intend to continue engaging MO&A for our major projects whenever the need arises and are willing to recommend it to others."

Moorhouse Properties Limited

iv. Mobil Oil Nigeria Limited

"Morgan Omonitan & Abe has offered an exceptionally professional service on our Head Office Development project to the total satisfaction of our overseas consultants based in New York and New Jersey who carried out regular reviews on all consultancy designs. We have been highly impressed by their standard of service and are proud to have appointed the firm. We urge that you consider MO&A for your real estate developments."

Mehtsun
Manager, Maroko Real Estate
Mobil Oil Nigeria Ltd.

v. Towry Coker Associates

"Recently, we were going through our archives and noted that on a significant number of projects Morgan Omonitan & Abe was the Civil and Structural Engineering Firm used. For instance, Savannah Bank, Lagos; Umarco Apapa, Dakar Road, Apapa, Residential Development for Modandola Group, CAPL Apapa, Idejo Close Mixed Development. You will notice that these buildings have stood the test of time both structurally as well as architecturally. We look forward to continuing excellent working relationship with professional engineers like yourselves, in the New Year."

Arc. L. Towry-Coker. FNIA. RIBA
(Principal)
Towry Coker Associates

vi. Nicon Hotels Limited

"On behalf of the Board, we wish to commend your firm for the excellent supervision and project management services resulting in the quality of works delivered by the Contractor Messrs. B. Stabilini Limited within the project cost. A letter of commendation will also be sent to the Contractor."

H.W. NIYO
General Manager/Chief Executive
Nicon Hotels Limited

TESTIMONIES CONT'D

vii. Nigeria Export-Import Bank

"Morgan Omonitan & Abe haa been duly registered as one of our Consulting Civil Engineering firms to be considered for the construction of our Head Office Projects in Abuja. An examination of the papers submitted by Messrs. MORGAN OMONITAN & ABE reveals that this company possesses the necessary experience, reputation and high caliber of staff with professional skills necessary for the provision of high quality service. These factors greatly influenced our decision to register the firm with our Bank."

P. U. Ajikohi
Manager, Administration/Personnel
Nigeria Export-Import Bank

50TH ANNIVERSARY

On July 3, 2022, MO&A officially celebrated 50 years of its establishment as one of Nigeria's most experienced and professional engineering consultancy firms. Some of the memorable pictures taken at the occasion are shown below:

MO&A 50th Anniversary Banner & Cake

MO&A Staff & Associates

Applause by MO&A Directors, L–R : Engr. Ayo Opasanya, Engr. Dapo Abe, Engr. Murray Ekong, in recognition and joy of a successful practice.

Staff Appreciation Award

Directors and Staff at the 50th Anniversary Celebration

THE WAY FORWARD

MO&A recently expanded the firm's footprints beyond Nigeria to Ghana and is taking great strides to firmly establish the MO&A legacy there.

In the years ahead, MO&A will continue with its track record of delivering best-in-class engineering consultancy services in its core areas of competence to the delight of current and future clients.

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QUALITY CONTROL IN HIGHWAY CONSTRUCTION

BY ENGR. KOLAWOLE OJO

1.0 INTRODUCTION

There are so many factors which are essential to the sustainability and integrity of highways. This paper will, however, focus on Quality Control Measures as they relate to highway integrity and sustainability.

Apart from the menace of armed bandits that are daily terrorizing highway users, the greatest menace is the disintegrated and deplorable state of highways in Nigeria. Solutions need to be proferred and implemented.

Engr. Kolawole Ojo *(CEO, Opiq Consultancy Services)*

2.0 QUALITY CONTROL

Sound material specification and quality control procedures coupled with strict adherence to these specifications in selecting road materials are worth examining.

The first procedure to be undertaken when a road contract is awarded is to visit the site to ascertain the availability and suitability of construction materials within the economic distance of the road corridors. The sources of construction materials include the source of water, location of borrow pits for earthworks and location of rock outcrop or underground deposits. The site camp should be appropriately sited.

The engine room for quality control is the Site Laboratory where all the sampled materials are tested before usage at the construction site. Some highway construction sites have no site laboratory and this does not augur well for effective quality control during construction. This aspect needs to be given attention in Nigeria.

3.0 HIGHWAY FAILURES

Most common failures occur due to lack of quality control. The common failures observed in most Nigerian roads include cracking of the pavement, stripping off of the surface and subsequent deformation of the pavement surface, sometimes only a few years after construction. The failures are due to poor material selection, inadequate compaction or poor drainage condition. Water also plays a major role by seepage through the pavement structure causing progressive increase in moisture content with consequent loss in shear strength and dry density. Another type of failure is surface deformation due to rutting. Rut seems to develop as a result of lateral push of the material away from the track of the wheels and this continues as long as there is no resistance against the lateral movement. Pot holes formation follows subsequently. The pot holes develop through road surface break-up due to uneven swell-up of some sub-grade material arising from increase in moisture either by percolation through the surface or by ground water rise.

The moisture increase may lead to considerable shear loss. Consequently, traffic impact readily causes deformation in the soil beyond elastic recovery. Such deformations and the accompanying settlements when repeated, result in the break-up of the surface with the eventual development of pot holes.

Landslide and erosion problems in cuttings and embankments are also common in Nigerian roads, especially, during the wet seasons. Notably, the performance of cutting slopes appears to depend on the type of parent rocks, degree of weathering, nature of soil and environmental conditions.

Other failures associated with Nigerian roads are edge failures. This type of failure is primarily due to the heavy duty vehicles parking at the shoulder thereby exerting enormous weight on the edge of the structure. In cases where they are not exerting weights, the drilling of diesel on the edgeways eventually percolates into the soil and worsens the failures in the form of cracking.

Inadequate treatment of some natural obstructions within the road alignment contributes in no small way to the road failures. Noticeable obstruction such as an outcrop plays a prominent role in this type of failure. When an outcrop is blasted within the carriageway by the use of an explosive, the tiny fragments of the rock particles create voids if they are not properly removed.

Figs. 1 – 4: *Typical road failures*

During load distribution, there is always a lateral movement of the material dump on the small rock fragments. This results in a shear failure of the road. Figs. 1 to 4 show typical road failures.

4.0 PREVENTION OF HIGHWAY FAILURES

Highlights of some of the measures to take note of are:
Highway Engineers should endeavor to get themselves acquainted with the General Specifications: Road and Bridges modified by the Federal Ministry of Works and the Contracts Documents governing Civil Engineering Works. This will no doubt help the young engineers as the scope of works defined for particular works or project.

Consulting Firms handling the design of highways should always visit the site at the preliminary stage of the design to see the existing condition of the road corridor. In the Kaduna – Kano Dualization project which was awarded in the eighties, the Consulting Firm, Obi Obembe and Associates provided details of all the borrow pits 500m interval on LHS &/RHS for filled materials and 300m interval on LHS/& RHS for sub-base and base course materials along the entire corridor of the road alignment.
Relevant professional bodies should step up quality control compliance efforts at project sites.

Figs. 5 - 8: *Soil laboratory equipment*

Emphasis should be placed on the usage of good laterite material for sub-base and base course be it sandy laterite, small pebble laterite, clayed laterite or rock laterite even if it involves additional cost at the instance of haulage as against stabilization of the material.

During the rainy seasons apart from civil works, contractors handling the earthworks should know that tipping of earth material without spreading may lead to moisture rise if there is rainfall over night. When this happens the material becomes plastic and it becomes impossible to achieve 100% compaction.
In asphaltic concrete works, control of bitumen content per total mix of all the other components is very crucial. The bitumen content per total mix as per design against the flow, stability, voids in total mix, voids filled with bitumen and density of the mix must conform to the laboratory mix design.

Contractors handling highway projects must ensure adequate curing facilities at the site for cube tests results of 7 days and 28 days strength must be clearly indicated in the format. This must comply with the specification. Slump test which shows the uniformity of the total mix must be strictly adhered to.
Client representatives must ensure that all these test results are attached to the interim certificates before approval is made.

5.0 STANDARD SITE LABORATORIES

A typical standard Material Laboratory can be sub divided into 3 groups, namely Soil Laboratory, Concrete Laboratory and Asphalt Laboratory
Figs. 5 - 8, Figs. 9 - 12 & Figs. 13 - 16 show sets of various laboratory equipment.

6.0 SITE LABORATORY TESTS

i. **Soil Laboratory:** The grading and the Liquid Limit test results give the soil classification. The California Bearing Ratio (CBR) is a measure of the strength of the sub-grade, sub-base and base course material used in the road construction. The filled material should be subjected to 48 hours of soaking, sub-base material 24 hours and base-course material un-soaked to achieve desirable results.

In-situ density test results give the degree of compaction of the various soil layers having obtained the optimum moisture content (OMC) and the maximum dry density (MDD) as a baseline.

ii. **Concrete Test Result:** The Cube test results at 7 days and 28 days give the strength of the material. Alternatively, the Non Destructive Rebound Hammer Test can be used to determine the strength of the concrete at a period exceeding the 28 days for greater reliability.

The slump test results give data on the uniformity of the total mix.

iii. **Asphalt Concrete Tests:** Bitumen Penetrometer test shows the level of penetration of the bitumen purchased. It is either 80/100 or 60/70 penetration. A situation where there is an interchange of the 2 depending on the work schedule can lead to severe consequences on the road. On the Kaduna – Kano Road project in the late 80s by the then Stirling Civil Engineering Ltd, 2 trucks of 80/100 were brought to the site and mistakenly added to the mix. This resulted in the bleeding of the finished asphalt with a subsequent sliding of the asphalt surface after a few months when the road was opened to road users.

Faulty screens on the Asphalt plant can lead to mis-representation of the plant mix.

Generally, constant checking of the control tests, especially, the extraction test results from the plant mix are very necessary because the increase or decrease in the bitumen content per total mix can have adverse effect on the finished asphalt surface.

Figs. 9 - 12: *Concrete laboratory equipment*

Figs. 13 - 16: *Asphalt laboratory equipment*

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ELECTRIFICATION PROJECT EXECUTION FOR HIGHWAYS

BY ENGR. M. OLANIYAN

Engr. M. Olaniyan *MNSE, C.Eng. (Partner, Tacas Associates)*

1.0 PREAMBLE

This treatise on "Electrification Project Execution for Highways" will focus more on street lighting provision for the highways. It is, however, good to note that technological advancement has led to the development of electric vehicles (EVs) which have now led to the consideration, design and provision of electricity on the roads/highways with numerous charging points for electric vehicles. Such a road is called 'eRoad'. Thus, essential aspects of electrification project for eRoad arising from the introduction of electric vehicles for transportation, will also be addressed.

2.0 INTRODUCTION

Some definitions will be useful in provoking clear understanding of what an electrification project for highways is all about.

2.1 ELECTRIFICATION DEFINED

Electrification is the process of powering by electricity and in many contexts, the introduction of such power by changing over from an earlier power source. Broadly speaking, electrification was the construction of electricity generation and electric power distribution systems that occurred in Britain, the United States and other developed countries from the mid-1880s until around 1950 and is still in progress in rural areas in some developing countries. The electrification of particular sectors of the economy is called by terms such as factory electrification, household electrification, rural electrification or railway electrification and in recent times, highway electrification.

2.2 PROJECT DEFINED

A project is defined as a specific, finite activity that produces an observable and measurable result under certain preset requirements.

It is an attempt to implement a desired change to an environment in a controlled way.

A project is a temporary, unique and progressive attempt or endeavor made to produce a tangible or intangible result (a unique product, service, benefit, competitive advantage, etc). It usually includes a series of interrelated tasks that are planned for execution over a fixed period of time and within certain requirements and limitations such as cost, quality, performance, among others.

2.2.1 The Key Characteristics of a Project

A project can be characterized as follows:

i. Temporary: This key characteristic means that every project has a finite start and a finite end. The start is the time when the project is initiated and its concept is developed. The end is reached when all objectives of the project have been met (or unmet if it is obvious that the project cannot be completed – then it's terminated).
ii. Unique Deliverable(s): Any project aims to produce some deliverable(s) which can be a product, service or some other result. Deliverables should address a problem or need analyzed before the project is started.
iii. Progressive Evaluation: As a project progresses, it should be subjected to continuous investigation and improvement with time. This key characteristic means that the successive iterations of planning processes will result in developing more effective solutions as deliverables for the project.

2.3 HIGHWAY DEFINED

A highway is any public or private road or other public way on land. It is used for major roads, but also includes other public roads and public tracks.

The general legal definition deals with right of use and not the form of construction. A highway is defined in English common law by terms such as "a way over which all members of the public have the right to pass and re-pass at all times without hindrance". In this context, the ownership of the ground is for most purposes irrelevant, thus the term encompasses all such ways from the widest trunk roads in public ownership to the narrowest footpath providing unlimited pedestrian access over private land.

3.0 ELECTRIFICATION PROJECT EXECUTION

3.1 PROJECT WORK BREAKDOWN STRUCTURE

In project management, the work breakdown structure (WBS) defines a deliverable-oriented hierarchical component of all the essential work to be executed by the project team to accomplish the desired objectives and create the required deliverables. It is made up of separate activities organized as packages or phases.

It is an organized and systematic way of illustrating a project in order to increase clarity. The main purpose of the WBS is to describe what works need to be done and how they all fit together within the context of the project. It is important for identifying the tasks that are necessary for successful completion of a project. It provides a clear understanding of what activities should be accomplished on specific dates.

A WBS can be used as a basis for finding the critical path and developing a network diagram that captures the flow of work needed to accomplish the project objectives.

3.2 PROJECT LIFECYCLE: COMMON PHASES

The concept of lifecycle is fundamental in project management. It describes the phases that a project goes through over time, from initial launch to completion and termination.

The project lifecycle includes all activities that an organization conducts to produce the final product. All of these activities should be considered equally important and they should be referred to as "steps" or "phases".

The value of project life-cycle management is that it defines what key stakeholders should be focusing on: 1) in each phase in order to progress the project to its next development step, 2) associated risks and challenges and 3) the effective leadership styles, team dynamics and strategies that support project success.

Depending on the company and the chosen method of project management, the project lifecycle can include these common phases:

i. Conducting a feasibility study: It is a phase meant to determine the viability of a project. The primary purpose of this phase is to identify the strengths, weaknesses and opportunities of the proposed project.
ii. Establishing the project requirements: This step identifies the functional and technical requirements from which a desired outcome or benefit will be produced. Defining project acceptance criteria is usually included in this step.
iii. Developing the project scope: This step defines what has to be done for the project, who will do it and how it will be done. This stage is also where the high-level project objectives should be defined.
iv. Creating the schedule and the budget — also called "project baseline": It refers to the level of detail of the project timeline and the estimated budget, including dates and time spans of each activity and the costs to be incurred. It also includes time buffers for contingencies to avoid delays in the start or delivery of the product.
v. Creating the project plan: The process of planning, organizing and scheduling the work assigned to a project is known as project planning. Its main aim is to ensure that the activities required to create and deliver a product are put in place in accordance with the allocated budget and deadline.
vi. Executing project work: It is also known as project implementation. The primary purpose of this phase is to ensure the completion of all activities and tasks in accordance with the project plan.
vii. Controlling and reporting: This phase consists of tracking progress, changing circumstances, risks, identifying issues plus monitoring the work performed during project execution. It can notify managers in case of any deviation from the plan.

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4.0 HIGHWAY LIGHTING

Highway lighting is the design and installation of street lights such that people can safely continue their travels on the road. Street lighting schemes never bring the same appearance of daylight, but provide sufficient light for people to see important objects required for traversing through the road. Street lighting plays an important role in:

- Reducing the risk of night-time accidents
- Assisting in the protection of buildings/property (discouraging vandalism)
- Discouraging crime

"In project management, the work breakdown structure (WBS) defines a deliverable-oriented..."

- Contributing to a secure environment for habitation

4.1 BASIC FEATURES OF STREET LIGHT LUMINAIRES

The basic features of street lighting luminaires are:

i. Roadway luminaires are mounted horizontally and thus have fixed vertical aiming.
ii. Roadway lighting luminaires have particular intensity distributions which are desired to light long narrow horizontal stripes on one side of the luminaire while minimizing the intensities on the other side of the luminaire.
iii. The intensity distributions up and down the narrow strip are generally the same. Any fixed aimed luminaire which does not have this type of intensity distribution is called an area luminaire.

4.2 MAIN OBJECTIVES OF STREET LIGHTING DESIGN SCHEME

The main objectives of street lighting design scheme are given below:

i. Perfect visual sensation for safety
ii. Illuminated environment for quick movement of the vehicles
iii. Clear view of objects for comfortable movement of the road users.

4.3 LAMPS ARE USED IN STREET LIGHTING

Various types of lamps are used in street lighting luminaires. They are:

i. High pressure sodium lamp
ii. Metal Halide Lamps
iii. Low pressure sodium lamps
iv. Incandescent Lamp (not recommended)
v. Light emitting diode (LED)
vi. Compact fluorescent lamp (CFL): This is used in lanes or streets but not widely.

4.4 MAIN FACTORS IN THE HIGHWAY LIGHTING PROJECT SCHEME

i. Luminance level should be adequate: Luminance always influences the contrast sensitivity of the obstructions with respect to the back ground.
ii. Luminance uniformity must be achieved: To provide visual comfort to the viewer's eyes, luminous uniformity is needed.
iii. Degree of glare limitation is always taken into design scheme:
Glare means visual discomfort due to high luminance. There are two types of glares created by the street light luminaires. The first type is disability glare and second type is discomfort glare. Disability glare is not a strong factor. Discomfort glare can be minimized through proper design.
iv. Lamp Spectra for visual sharpness depends on the proper luminaries which must have appropriate dimension.

4.5 TYPES OF ROADS TO IMPLEMENT STREET LIGHTING DESIGN SCHEMES

According to CIE 12, roads are broadly classified into five types for street lighting design schemes.

Type A of Street Lighting Design (for expressways)

- Heavy and high-speed traffic.
- The roads are separated with the separators.
- No crossing is allowed.
- Controlled access

Type B of Street Lighting Design (for trunk roads)

- Heavy and high-speed traffic
- Separate road for slow traffic movement or pedestrians

Type C of Street Lighting Design (for ring road or radial road)

- Heavy mixed traffic with moderate speed
- Rural and urban roads

Type D of Street Lighting Design (for shopping streets)

- Road for slow traffic and pedestrians
- Road in the city or shopping center

Type E of Street Lighting Design (for local street)

- Mixed Traffic with limited speed
- Connector road between residential areas

"There are two types of glares created by the street light luminaires. The first type is disability glare and second type is discomfort glare."

4.6 POLE ARRANGEMENT SCHEMES IN STREET LIGHTING DESIGN

4.6.1 Single Sided

When the width (W) of the road is nearly equal to the pole height (H), i.e., W = H then the poles are arranged on one side only. Generally, pole height available is 10 meters. The span between two poles is equal to the road width. See Fig. 1.

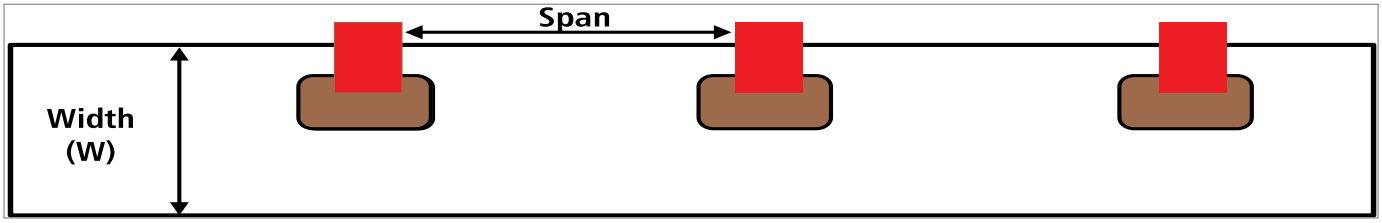


Fig. 1: *Light poles on one side*

4.6.2 Double Sided

When the width (W) of the road is nearly double the pole height (H), i.e., W = 2H then the poles are arranged along both sides opposite to each other manner. The span between two poles may not be equal to the road width. See Fig. 2.

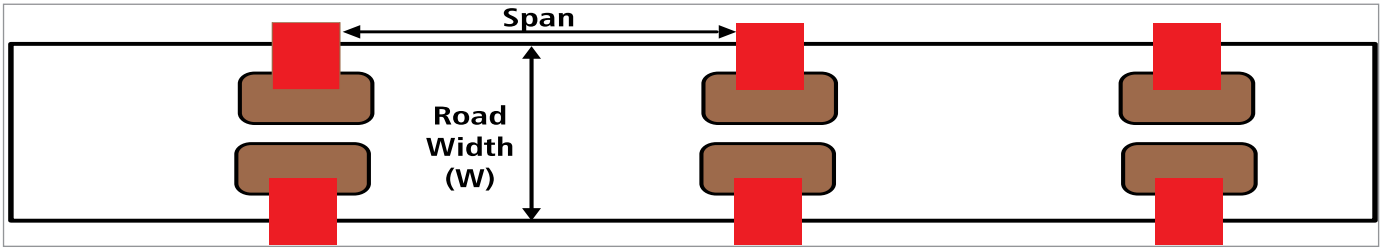


Fig. 2: *Light poles on both sides opposite to each other*

4.6.3 Staggered Sided Or Zigzag Pattern

When the width (W) of the road is nearly 1.5 times of the pole height (H), i.e., W = 1.5 H then the poles are arranged in both sides in zigzag manner. The span between two poles may not be equal to the road width. See Fig. 3.

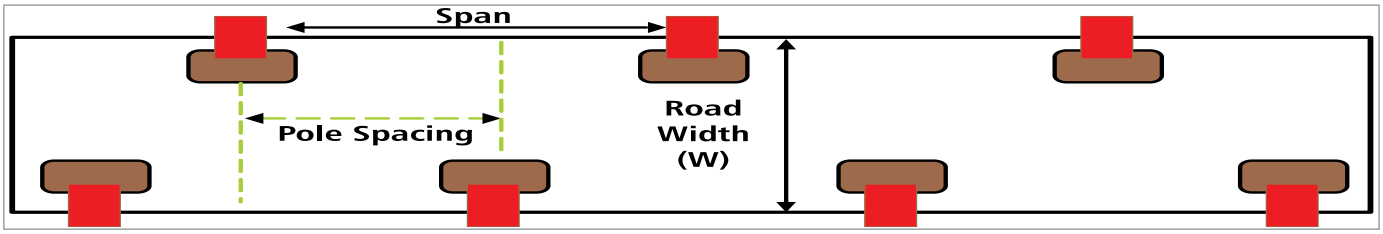


Fig. 3: *Light poles in zigzag arrangement*

4.6.4 Central Verge Position

When the width (W) of the road is much greater than the pole height (H), i.e., W>>H the poles are arranged in the central verge of the road.

The luminaires are made to face both road surfaces from the central verge. See Fig. 4.

The span between two poles may not be equal to the road width.

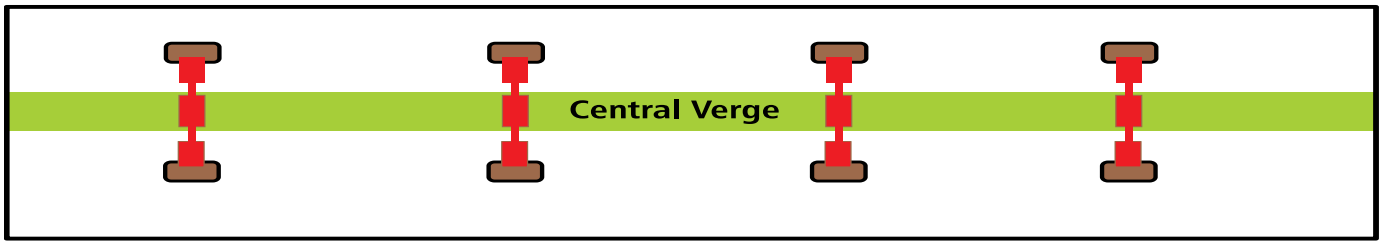


Fig. 4: *Kight poles in central verge*

5.0 ELECTRIFICATION OF eROAD (HIGHWAY) FOR ELECTRIC VEHICLES

It is incumbent upon the transport sector to reduce its CO2 emissions by replacing fossil fuels with low-carbon alternatives. Suggested strategies include the use of electric vehicles (EVs) with static charging, electric road systems (ERS) and the use of electricity to produce fuels.

Electrification of highways has created new electricity load profiles that depend on the time of consumption and the amount of electricity used in EVs. Electric vehicles are also gradually contributing, with flexibility, to the electricity system – a feature that will be of increasing importance with a higher share of variable renewable electricity (VRE) in the electricity industry.

Electric engines are increasingly seen as an important technology to reduce the carbon footprint of the transportation sector. It should be noted that utilizing electric commercial vehicles (ECVs) for long-haul freight transportation is a challenging task. The battery capacities of ECVs successfully applied for urban logistics with driving range between 130 to 160 km is too small for long-haul transportation where frequent recharging stops impede on-time deliveries. On the other hand, larger batteries enabling sufficient driving ranges are so heavy that they considerably reduce the maximum payloads of ECVs. These limitations have triggered a recent consideration of 'charge-while-drive' technology for road-based long haul.

Overhead wires are an old established technology to transmit electrical energy to trams, trolleybuses and trains via roof-mounted current collectors, e.g., pantographs or trolley poles. Even in truck-based freight transportation, catenary trucks, also denoted as trolley trucks, have a long-lasting history and are still successfully applied in large mining projects.

In 2012, Germany's largest industrial manufacturing company Siemens has announced its eHighway concept, which transfers these previous approaches to public-road freight transportation. Three of the catenary hybrid trucks applied in this concept are depicted in Fig. 5.

In addition to an electric motor, powered via the overhead wiring and an automatically connecting pantograph, a conventional engine or a battery which can serve in a range of about 50 to 100 km is applied to allow overtaking and access of roads without overhead lines. First test tracks on public and private roads have been erected in Germany, Sweden and the US. An alternative 'charge-while-drive' technology is currently tested in Sweden. See Fig. 6. Here, a road-embedded power line is applied, accessed by a movable contact arm mounted under the vehicles.

'Inductive charge-while-drive' technology without direct contact is becoming available on public roads.

Fig. 5: *Catenary hybrid trucks*

Fig. 6: *A road-embedded power line being constructed*

The world's first electrified road that recharges the batteries of cars and trucks driving on it was in Sweden.

Highway electrification is not without its problems and challenges. The main challenge is the huge cost which is presently high. For the overhead wire system, for instance, estimates for the costs per (bidirectional) km fall in the range of 1.7 to 3.1 million Euro. This is about N910M to N2.17B per kilometer.

6.0 CONCLUSION

Electrification of highways and in particular, the eRoad concept, is the future of transportation in the world at large. Proper planning and policies should be considered by the Nigerian government from now so the country can be relevant in future.

DRAINAGE SYSTEMS DESIGN AND EXECUTION FOR HIGHWAYS

BY ENGR. HENRY CHUKWUDI OKPALA

Engr. Henry C. Okpala, *FNSE, FNICE, FNIHTE, FIMC, KGS (Principal Consultant, Hecon Consultants)*

1.0 PREAMBLES

This topic in engineering parlance is broad, because drainage systems are numerous. In Sanitary Engineering we have drainage systems, in Irrigation and Environmental Engineering we have drainage systems, in Geotechnical Engineering we have drainage systems, in Building Structures we have drainage systems, in Highway Engineering we have drainage systems. In order to fall within the purview of my required presentation, I will concentrate on the design of Highway Engineering drainage system and execution.

1.1 DRAINAGE SYSTEMS

The design of drainage structure is based on the science of hydrology and hydraulics.

The former deals with the occurrence and form of water in the natural while the later deals with the science of the laws of motion of water and other liquids and of their practical applications.

Types of Drainage Systems

i. Surface Drainage Systems: Surface drainage systems remove excess water from the land's surface through channels or ditches
ii. Subsurface Drainage System
iii. Slope Drainage System
iv. Downspouts and Gutter System.

There are two major types of drainage systems

a. Surface Drainage System
b. French Drains consisting (ii), (iii) and (iv)

a. **Surface Drainage Systems:** Consist of a few ground-level area drains that are connected to PVC piping. When it rains, water flows down the drains into the piping and transmit to an approved location.

b. **French Drains:** Consists of an underground passage for water. It is constructed by filling a trench with loose stones, bricks or rocks and covering with earth. It can also be called rubble drain.

We will dwell more on French drains with particular reference to a type 4 drainage system. Generally it is known and called gutter system by a lay person while in Highway Engineering it is usually called line drain. You may wish to note that structural column is called pillar by a lay person.

2.0 DRAINAGE SYSTEM DESIGNS

This paper focuses on line drain design of highways.

1. The design information is from actual survey work of the project areas, without which nothing feasible will be achieved/designed.
2. The plan area will be analysed to note the paved area percentage and unpaved (grassed) area percentage to the overall catchment area considered for the storm run off.
3. An important aspect is contact with the nearest hydrologic station covering the area billed for the design for records kept on hydrologic studies (See Fig. 1).

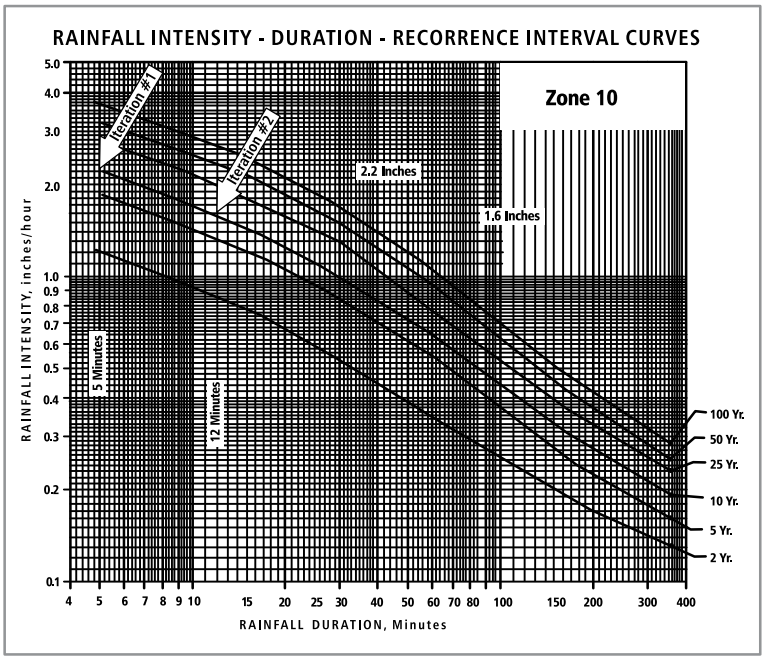


Fig. 1: *Use of I-D-R Curve*

4. Also, an important aspect is contact with the nearest Government Ministry covering the area in question for their own rain fall records.

RURAL LAND USE	LOWER BOUNDS	UPPER BOUNDS
Cultivated Land, Sand & Gravel Soils	0.25	0.35
Cultivated Land, Sandy Loam Soils	0.20	0.52
Cultivated Land, Clay & Silt Loam Soils	0.40	0.72
Cultivated Land, Tight Clay Soils	0.50	0.82
Pasture, Sandy loam Soils	0.10	0.22
Pasture Clay & Silt loam Soils	0.30	0.42
Pasture tight Clay Soils	0.40	0.60
Meadow	0.10	0.50
Woodland, Sandy loam Soils	0.10	0.30
Woodland, Clay & Silt Loam Soils	0.30	0.50
Woodland Tight Clay Soils	0.40	0.60
Rock	0.82	0.94
Desert	0.30	0.55
Urban Land Use	**Lower Bounds**	**Upper Bounds**
Parking	0.85	0.96
Commercial	0.71	0.89
Streets	0.70	0.91
Industrial	0.67	0.86
Residential Lots, High Density	0.25	0.54
Residential Lots, Medium Density	0.19	0.50
Residential Lots, Low Density	0.14	0.46
Railway Yards	0.20	0.35
Playgrounds	0.20	0.30
Sports Field	0.20	0.35
Parks	0.10	0.25
Cemeteries	0.10	0.25
Man-Made Surfaces	**Lower Bounds**	**Upper Bounds**
Roofs, Steeply Sloping	0.90	0.95
Roofs, Small Flat	0.90	0.95
Roofs, Large Flat	0.75	0.95
Asphalt	0.70	0.95
Previous Asphalt	0.55	0.80
Concrete	0.70	0.95
Previous Concrete	0.60	0.80
Concrete Blocks, Uncemented Joints	0.50	0.70
Concrete Blocks, Cemented Joints	0.70	0.85
Gravel	0.50	0.60
Earth	0.50	0.50
Grass, Poor Condition	0.32	0.62
Grass, Fair Condition	0.25	0.60
Grass, Good Condition	0.21	0.58
Turf Block	0.15	0.30

Table 1: *Typical run-off coefficient data*

METHOD 1

By using one of the empirical or exponentials formular applicable to the region.

e.g. $Q = a A^m$

Where Q = The average flow from the basin having a drainage area equal to A.
a and m are coefficients determined by the factors than the size of the drainage area.

This is also known as **regression analysis method.**

METHOD 2

By using a rational method involving the rainfall and other characteristics for the area.

Q = CIA (Imperial) or Q = CIA (Metric)
Where Q = Maximum flood discharge in m^3 per hr. or m^3/second
A = Catchment area in km2 for small watershed < 10km2
I = Peak intensity of rainfall in mm/hr.
C = Runoff coefficient (See Table 1)
Note: These few conversions
1 Ha = 104m^2;
1 Acre = 0.4047Ha
1 Acre = 4047m^2 (4000m^2)

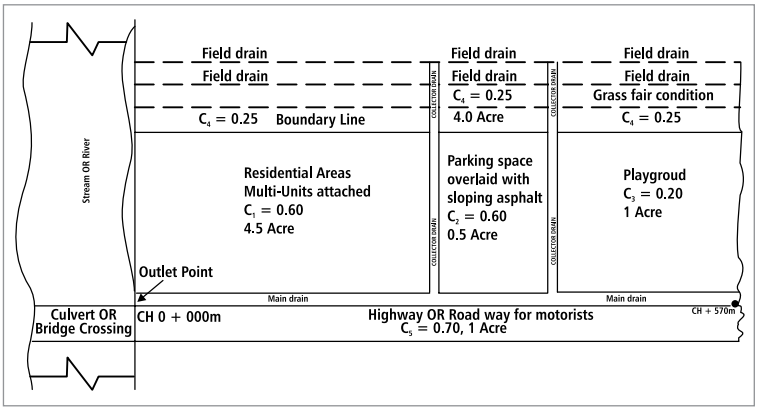


Fig. 2: *Sketch of a drainage basin showing systematic layout illustration of drainage systems.*

Notes on the above diagram

1. The field drainage system is a network that gathers the excess water from the land by means of field drains, possibly supported by collector drains to promote the flow of excess water to the main drain (see Fig. 2).
2. The main drainage system is a water conveyance system that receives water from the field drainage systems, surface runoff, and groundwater flow, and transports it to the outlet point.
3. Outlet is the terminal point of the entire drainage system from where it discharges into a river, stream, lake or sea e.t.c.

Note: Minimum time of concentration is 5 Minutes.

From the above diagrammatic illustration, our main duty is to design for the main drain. The drainage basin is divided into three major components:-

1. Field drainage systems with collector drains that bring runoff into the main drain.
2. Main drainage system that receives all runoff from the illustrated watershed or catchment area.
3. Definitely there must be an outlet where the stormwater/runoff empties.

The region/area that is not captured by the survey topography has it's slope or gradient contour lines towards another catchment area/watershed.

Finally, runoff is influenced by rainfall that flows over paved and unpaved, pervious and impervious land/soil characteristics.

3.0 DESIGN CONSIDERATIONS

1. ***First Phase:*** To establish the survey layout/plan that covers the watershed/catchment area needed for runoff calculation. Also to determine the different areas with different values of runoff coefficients say C_1, C_2, C_3 etc. with their respective areas eg. A_1, A_2, A_3 etc. The weighted value of the runoff coefficient C for the catchment area is given by

   $C = (A_1 C_1 + A_2 C_2 + A_3 C_3 + ...) (A_1+A_2+A_3+.....)$

   (See Table 1)

2. ***Second Phase - Hydrologic Design:*** To estimate the maximum quantity of runoff water expected to reach the main drain under consideration.

   $\mathbf{Q = CIA_d}$

   The intensity of rainfall I is calculated from the IDR curve OR IDF curve. (intensity duration recurrence interval OR frequency) curve.
   See sample graph/chart attached.

3. ***Third Phase – Hydraulic Design:*** Objective: Design of Drain Using Manning's Formula.

   $Q = AV$

   $A = Q$

   $$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} \qquad R = \frac{A}{P}$$

   Where:

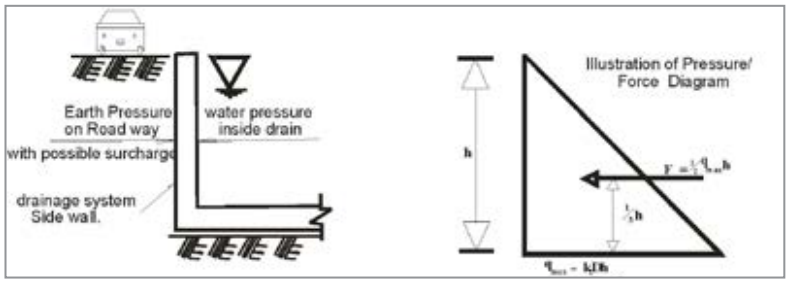
   V = *velocity of flow in open channel flow condition*

   n = *the coefficient of roughness*

   R = *Hydraulic radius and*

   S = *Slope for chezy's equation.*

4. ***Fourth Phase – Structural Design:***
   The design is considered as earth and water retaining wall and is designed as a Cantilever structure (see Figs. 3 & 4).



Figs. 3 & 4: *Drainage system sidewall and pressure/force diagram*

5. ***The Execution of Drainage System for Highways:***
   The execution of designed drainage system on highways is usually rectangular, trapezoidal, V-shape and circular (see Fig. 5). The most common one is rectangular drainage system and that is the one I will consider.

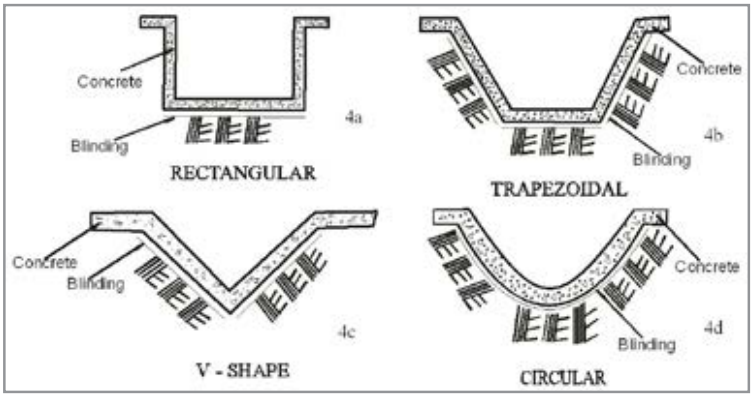


Fig. 5: *Shapes of drainage systems*

There are basically two major modes of execution.

1. Pre-cast execution.
2. Cast-insitu execution

Pre-Cast Type

The formwork, mould and curing of the pre-cast concrete itself are done in the company's factory yard and stacked until the site is ready for installation.

Cast-Insitu Type

This type is executed directly at the roadway site and the casting of concrete is done immediately the blinding, the reinforcement and formwork are ready.

The formwork are removed as soon as the contractor needed it for continuous work. While the period of curing is allowed before backfilling the side with earth material. Serious compaction is done especially at the side of the roadway to avoid sinking, immediate or consolidated settlement in future.

4.0 DESIGN CALCULATIONS

The diagrammatic illustration as in Fig. 1 is not a case study but given as a guide to enable the reader appreciate the sequence of the designer's procedure. By studying the diagram in fig 1 using my presentations with typical runoff coefficient table and IDR or IDF curve, you can generate any required data symbol using available equations/ formulae. Assumptions offer field work.

i. Design data after field work

I = 9.75mm/hr
A = 4.4Ha
C = Coefficient of Runoff 0.65
Q = CIA..... Equ D - 1
360
Q = 0.65 x 97.5 x 4.4 = 0.77m³/s (27.3cfs)
360

For cfs unit = Q = C x in/hr x Acres
Discharge Conversion = 1m³/s = 35.40 cfs

ii. Hydraulic Design of Channel

$Q = VA = \frac{1}{n} AR^{\frac{2}{3}} S^{\frac{1}{2}}$ ..... Equ D - 2

A = Cross-sectional area of flow in m2.
V = Velocity of flow.
Q = Discharge that flow in the channel.
n = Manning's roughness coefficient.
s = Friction slope
y_n = Normal depth of flow

Q = 27.3 cfs
n = 0.013 concrete channel coefficient.
b = 1m = bottom width of drain
b = 1m: 3.281ft = bottom width of drain assumed.

Slope S based on site survey = 0.0005
[say CH 0 + 000m to CH 0 + 570m]

$$\frac{AR^{2/3}}{b^{8/3}} = \frac{Q \times n}{1.49\, S^{1/2} b^{8/3}} \quad \text{------- Equ D – 3}$$

Ref Art.. 6 – 6B, PP 142

Open channel Hydraulics. Ven Te Chow.

Now substituting

$$\frac{AR^{2/3}}{b^{8/3}} = \frac{27.3 \times 0.013}{1.49\,(3.281)^{67}\,(0.005)^{\frac{1}{2}}} = 0.466$$

$y_n/_b = 0.960$
Ref. Fig 6-1, PP 130
yn = 0.96m

The finished height of drain shall be above normal flow depth. I should design with 1.2m as finished height (y_d).

Check Velocity
Water area = b y_n
= 1m x 0.96m
= 0.96m²
Velocity = V = $\frac{Q}{A} = \frac{0.77}{0.96}$ m³/s / m²
= 0.8m/s = OK

iii. Structural Design and Detailing

The design is considered as a cantilever retaining wall. Earth on one side and water on the other side. I should quickly consider the critical side that retained earth material and possibly surcharge (see Fig. 6).

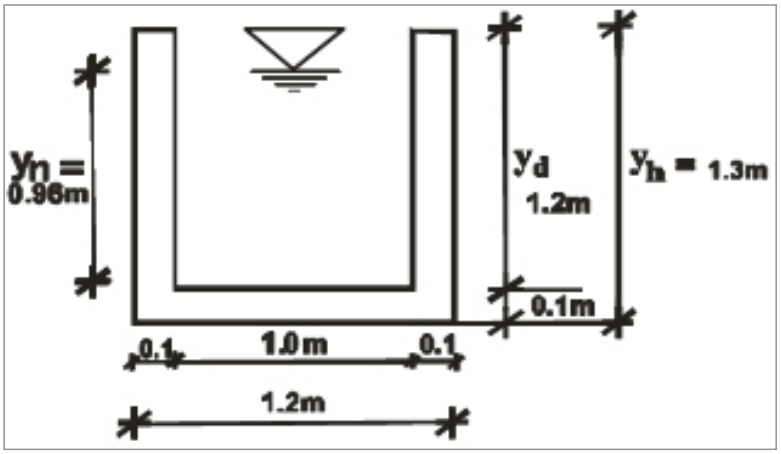


Fig. 6: *Structural design detail*

From Table 17, Table 18 and Table 192 of Reynolds 9th Ed. I selected the following:

D = 18.9KN/m3 (Unit weight of retained material)
K2 = 0.589 (frictional coefficient based on angle of repose)

Angle of internal friction or angle of repose 15⁰
Allowable soil pressure (Bearing Pressure) = 160KN/m²

iv. Line Drain Wall Design

Overall height y_h = 1.3m

Note: 2400Kg/m³ = 24KN/m³ (Density of reinforced concrete)

Dead weight of wall – assumed thickness 0.1m

0.1m x 24KN/m³ = 2.4KN/m²

Soil loading is dead weight = 18.9KN/m³ x 1 m span = 18.9 KN/m²

Total dead weight = (2.4KN/m² + 18.9KN/m²) = 21.30KN/m²

(1 m span)

Load factor for dead weight 1.4

Surcharge is treated as live load with load factor 1.7

The triangular soil pressure is zero at the top q_o and q_{max} at the bottom.

$\therefore q_{max}$ = K2Dh

q_{max} = 0.589 x 21.30 x 1.3 x 1.4

= 22.83KN/m

$\therefore$ *The force for the triangular shape*

F_{dead} = ½ q_{max} h = 0.5 x 22.83KN/m x 1.3m

= 14.84KN (for 1 m span of the wall)

Consider Surcharge:

Maximum load for wheeled vehicle is usually 40 tonnes, while for tracked vehicle = 70 tonnes.

Wheeled vehicle is considered in this design.

Take the area of 40tonnes spread to be 12m x 7.3m = 87.6m²

Applied unit area force due to surcharge q_s

$\therefore$ qs = $\frac{40 \text{ tonne}}{86.6\text{m}^2}$ = 0.4 tonne/m²

1 tonne = 1000kg

1 kgf = 1kgwt = 9.8N approx. 10N = 0.01KN

$\therefore$ 0.457tonne = 4.57KN

Load factor for Live Load = 1.7

F_{live} $\therefore$ 4.57KN x 1.7 = 7.77KN (1m length of wall)

F = F_{dead} + F_{live} = 14.84KN + 7.77KN = 22.61KN

Finding moment at the foot of the drain wall

$M_{max} = \frac{F \times h}{3} = \frac{22.61\text{KN} \times 1.3\text{m}}{3} = 9.8\text{KN OR } 9.8\text{KN/m}$ **(1m lenght of wall)**

Finding or calculating steel reinforcement

$$As = \frac{M_{max}}{0.87\, fy\, Z}$$

Where Z is the lever arm

And fy = 425N/mm2 high yield

$Z = \frac{3}{4} d$

d = 100 - 40 - 5 = 55mm

cover $^{o}/_{2}$

Z = 0.75 x 55 = 41.25mm

$As = \frac{9.80 \times 10^6}{0.87 \times 425 \times 41.25} = 642.53\text{mm}^2/\text{m}$

From design table use Y10 at 100mm c/c spacing

Ast = 785mm²/metre run

Distribution Steel

As_{min} 0.12 % bh – high yield

As^{min} = 0.12 x 1000 x 100 = 120mm²/m100

From design table use Y8 at 150mm c/c spacing

Ast = 335mm²/metre run

Detailing

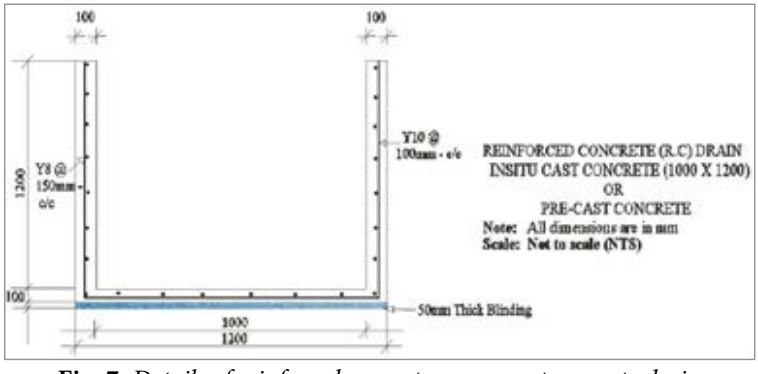


Fig. 7: *Details of reinforced concrete or pre-cast concrete drain*

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PLASTIC HIGHWAYS

BY ENGR. ENEFIOK UBOM

Engr. Enefiok Ubom, FNSChE

1.0 INTRODUCTION

The world of plastics has widened beyond toys, plates, spoons, forks, bottles, basins, funnels, chairs and tables. Most vehicles and boats have considerable amounts of plastic components. Alas, the world is now witnessing the use of plastics in highway or road construction. Plastic highways are made entirely of plastic materials or composites of plastic with other materials. Plastic highways are different from standard highways in the sense that standard highways are made from asphalt concrete which consists of mineral aggregates and asphalt. On the other hand, a plastic highway is generally of two types:

i. Plastic highways consist of modular, hollow and prefabricated road elements made from consumer waste plastics.
ii. Plastic highways consist of an asphalt mix with plastic waste incorporated into the asphalt mixture.

2.0 INITIAL DEVELOPMENT

The technology was initially developed and patented by Rajagopalan Vasudevan of the Thiagarajar College of Engineering. He developed an innovative method to reuse plastic waste to construct better, more durable and very cost-effective roads. This method makes road construction much faster and saves the environment from dangerous plastic wastes. The roads also show greater resistance to damages caused by heavy rains.

Plastic roads first developed by Rajagopalan Vasudevan in 2001, consisted of an asphalt mix with plastic waste incorporated into the asphalt mixture. The implementation of plastics in roads opened a new option for recycling post consumer plastics.

3.0 INDIA AND UNITED KINGDOM AS EXAMPLES

3.1 INDIA

Chennai was among the first cities globally to adapt the plastic road technology in a big way when the municipality commissioned 1,000 km of plastic roads in 2004. The first plastic road in Tamil Nadu was constructed in Kambainallur, a Panchayat Town of the Dharmapuri District. Since then all major municipalities in India have experimented with the plastic road technology as further described below.

Chennai has used nearly 1,600 tonnes of plastic waste to construct 1,035.23 kilometres length of roads in recent years.

In Pune, with the use of bitumen technology on waste plastic, the Pune Municipal Corporation constructed a 150-metre stretch of Bhagwat lane at Navi Peth near Vaikunth Crematorium in 2016. The other trial patches in Pune include Dattawadi Kaka Halwai Lane, Katraj Dairy, Magarpatta City HCMTR Road, Kavde Mala Road, Koregaon Park Lane No 3 and Yeravada Sadal Baba Darga Road from Chandrama Chowk.

In Jamshedpur, the Jamshedpur Utility and Services Company constructed a 12 – 15 km road in its steel city using plastic material, including a nearly 1 km stretch in Ranchi, 500m stretch each in Dhurwa and Morabadi, 3 km of roads in Chas and Jamtara each and 500m stretch in Giridih.

In 2014 at Indore, the Madhya Pradesh Rural Road Development Authority constructed about 35 km of roads in 17 districts with plastic waste. In Surat, the idea of using plastic-bitumen mix was executed in January 2017. The problem of potholes significantly reduced as no cracks developed in areas where roads were constructed with waste plastic.

As at December 2019, India has built 21,000 miles of roads using plastic waste. Until now, the country has almost 33,700 km of plastic roadways that means every 1 km road uses one million plastic bags

3.2 UNITED KINGDOM

In January 2019, the Department for Transport announced a £1.6 million UK trial of a plastic road technology developed by MacRebur, an asphalt enhancement company based in Scotland.

In MacRebur's process, anywhere between 3 – 10 kg of waste plastic is used in each ton of asphalt. The aim of the initiative is three-fold: to use the millions of tons of plastic waste currently sitting in UK landfills, to reduce the millions of pounds of government money spent on new roads, maintenance and pothole repair and to make roads stronger and durable.

MacRebur's technology includes the patent-pending MR6, MR8 and MR10, all of which use a carefully selected mixture of polymers, specifically designed to improve the strength and durability of asphalt and reduce the quantity of bitumen required in the mix. The polymers are made from 100% waste materials and are used in the making of both hot and warm mix asphalt. The method of manufacture for these polymers means they contain no micro-plastics.

4.0 SOME PICTURES OF PLASTIC HIGHWAYS

Figs. 1 – 3 show pictures of some plastic highways.

Fig. 1: *Plastic highway in Australia*

Fig. 2: *First highway paved with recycled plastic in Mexico*

Fig. 3: *California highway paved with plastic*

5.0 MERITS AND DEMERITS OF PLASTIC HIGHWAYS

5.1 MERITS

i. Plastic roads can have hollow space built in to allow ease of wiring, connecting pipes, etc.
ii. Since plastics come with various chemical and physical properties, roads can be engineered to meet specific requirements (e.g. weather and wear resistance).
iii. Plastic roads can be built from waste plastics instead of dumping them in landfills or burning them in incinerator. Land-filling and incinerating plastic are both problematic methods of managing plastic waste. Plastics in landfills can leak pollutants into the surrounding soil. Incinerating creates gaseous pollutants such as carbon dioxide.
iv. Plastic-bitumen composite roads need not be especially discriminating with the plastics used, thus increasing the reuse of plastic.
v. Use of plastic translates to using less asphalt and this saves on cost and resources.
vi. The addition of plastic in asphalt can reduce the viscosity of the mix. This allows a lower working temperature, which lowers volatile organic compound (VOC) and carbon monoxide (CO) emissions.
vii. Plastic-bitumen composite roads have better wear resistance than standard asphalt concrete roads. They do not absorb water, have better flexibility which results in less rutting and less need for repair. Road surfaces remain smooth, require lower maintenance and absorb sound better.

5.2 DEMERITS

i. Pure plastic roads require use of compatible plastics because, when melted, plastics of different types may separate in phases and cause structural weaknesses, which can lead to premature failure.
ii. Plastics in the road can break down into micro-plastics and can find their way into the soil and bodies of water. These microplastics can also absorb other pollutants.
iii. Every time maintenance is performed on these modular roads the flow of electric power, water and internet whose cables have been installed within will be interrupted.

6.0 CONCLUSION

In view of the merits in plastic highways, this option in highway development and construction is worth being explored in Nigeria on a trial basis. Specifically, the use of MacRebur's technology can be explored provided it is well verified from current users that the absence of micro-plastics in its process method leads to non-seepage of such micro-pollutants into the soil and bodies of water in the course of time.

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