THE ASSOCIATION FOR CONSULTING ENGINEERING IN NIGERIA (ACEN)

# THE Consulting Engineer

A Four-Monthly Publication of The Association for Consulting Engineering in Nigeria (ACEN)
**January - April 2021 | Vol. 8 | No. 1 | Engineering is Development**

## ENGINEERING MANAGEMENT

INSIDE



SAMABOT & ASSOCIATES SUPPLEMENT

PERSONALITY INTERVIEW
Engr. (Dr.) J. I. Folayan

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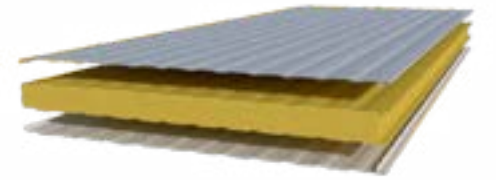

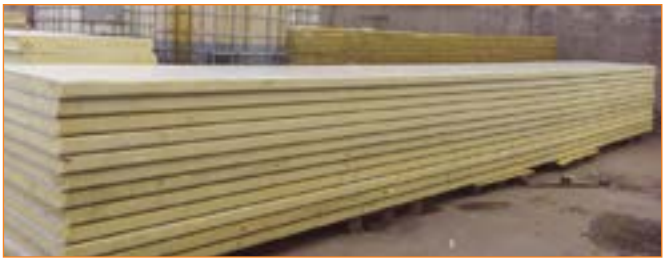

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THE
# Consulting Engineer



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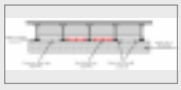



# FROM THE EDITORIAL SUITE

***Engr. F. Ajibade Oke,*** *FNSE*

We are glad to welcome our esteemed readers to Year 2021. The theme of the first edition of our magazine for this year is "Engineering Management".

Engineering Management is a subject dear to the hearts of practitioners of Engineering Consultancy. This is because engineering consultancy firms operate as business entities and they need to have the capacity to apply the knowledge of Management to the firms' operations so as to achieve business targets. We can describe this notion as Engineering cum Management in operation.

Leaning on the above notion, we are serving you with various articles which address different aspects of Engineering Management. The first article "Aligning Nigerian Consulting Engineers with Best Practices in Corporate Governance" by Engr. Ibikunle S. Ogunbayo, FAEng, FNSE, Chairman of KOA Consultants Limited, emphasizes the need for managers of engineering consultancy firms to proactively adopt corporate governance practices in order to be better positioned to achieve results that satisfy all stakeholders.

On the government side, public private partnership as a way of delivering and managing public infrastructure, is presented under the topic "Public Private Partnership Framework and Implementation in Nigeria" by officials of Infrastructure Concession Regulatory Commission (ICRC), namely, Engr. Chidi K. C. Izuwah, Snr., Director General/CEO, Barr. Joe A. M. Ohiani, Director, Public Private Partnership Resource and Mr. Felix O. Ogbera, Deputy Director, Revenue, Investment & Project Finance.

Various other authors have presented articles as follows:

- Engineering Management in Construction of Dams by Engr. Imo Ekpo, FNSE, FNICE, Principal Partner, Micek Consult Limited
- Engineering Management in Road Construction by Engr. Idowu Aderibigbe, MNSE, Principal Partner, Joint Konsult
- Engineering Management in Factory Operations by Engr. Yemi Mofikoya, MNSE, General Manager, Vitapur Nigeria Ltd
- Engineering Management of Electrical Projects by Engr. Marcus Olaniyan, MNSE, Partner, Tacas Associate Consulting Engineers
- Bridge Design and Construction Management by Engr. Aileme Unuigbe, MNSE, Principal Engineer, AICOL Consulting Engineers
- Engineering Management of Thermal Power Plants by Engr. Agha Ogbonnaya, Head of Plant Services, Planning and Technical Training, Afam Power PLC.
- Special supplement is presented on Samabot & Associates Ltd headed by Engr. Sam Otenaike, FNSE. The firm has distinguished itself as an excellent performer n engineering industry in Nigeria.
- ACEN events including their associated memorable pictures presented in the edition include:
- 2020 Annual General Meeting
- Courtesy visit to Niger Delta Basin Development Authority

A personality interview was conducted with Engr. (Dr.) Joseph I. Folayan, FAEng, FNSE, Past President of ACEN. The record of this interview contains far reaching lessons for all and sundry, particularly engineers, young and old. Undoubtedly, Dr. Folayan is an iconic figure in engineering industry and there is much for readers to learn from him.

The Tit-bits column characteristically adds some luster to this popular magazine. In this edition, you will read Engr. Enefiok Ubom's lucid presentation on what happens in a specific animal world as well as a technological feat in a unique infrastructure demolition exercise, all in the context of engineering management.

We extend our deep appreciation to all stakeholders who contributed to the successful publication of this edition.

***Please continue to stay safe and enjoy your reading***

***Engr. F. Ajibade Oke,*** ***FNSE***
*(Chairman, Editorial Committee)*

# A MESSAGE FROM ACEN PRESIDENT

*Engr. George. C. Okoroma, FNSE, JP*
*(President, ACEN)*

Dear Readers,
Despite the economic challenges brought on us by the upsurge of the novel coronavirus pandemic, we weathered the storm, charted new courses, and innovated strategies that helped our businesses overcome the havoc of the pandemic. To the glory of God, not only did our businesses survive the upsurge of the virus, but amidst all odds, every one of us in the ACEN engineering family made it to the New Year 2021, and we are bouncing back stronger than ever.

I want to, on behalf of Exco and Council, heartily welcome you to a brand New Year 2021 and wish you good fortune and abundant prosperity in all consultancy services and life's pursuits in the New Year. Be rest assured of our esteemed support for you and your firm.

At the moment, there is a new wave of a resurgence of the virus in our major cities. This shows that the battle is not over yet, but I am confident that as we have done in the past, we would do better now in adopting technology and tools, and subscribe to new and fast methods of projects delivery that is timely, within budget and that will help keep our nation's economy at par with other nations of the world, as we work in unity to recover from the quagmire that the pandemic led us into.

The New Year is going to be very demanding and busy for us, with opportunities for each according to ability or achievement. Nothing shall be impossible for us if we are resolutely willing to pay the price of commitment, dedication and discipline. In the weeks and months ahead, we would continue to work hard and give our best in mitigating new challenges and strategizing to better deliver on our promises.

Our goal since inception in 1971 has been to become the number one adviser to the Government and private sector in areas of sustainable infrastructural development, resilient designs, project planning, financing, supervision and liaison. There is no better time than now for us to live up to expectations. We must remain hungry for knowledge, and commit to a continuous and a never-ending professional development strategy. While we are hopeful that total normalcy would return to our cities and other nations of the world in the shortest possible time, we would continue to harness top-grade technology to deliver our meetings and events, where face-to-face contact is not possible. This year is going to be remarkable in our history, as ACEN would be 50 years in existence as an association in Nigeria. It is going to be a Golden Jubilee of successful records and great achievements in the engineering development of Nigeria. At the end of this year, we would be looking at welcoming our new President and the fresh crop of Council and Exco members who would further stir the affairs of this great association.

Amidst the turbulence that we experienced last year, our bond of ethical cooperation and unity of purpose was strong. We rallied around each other, harnessed technology to host major events, and we were at par with our counterparts within and outside Nigeria. In this New Year, my team and I would covet more of your cooporation, support and concern for one another.

No firm member is alone. We are together in the struggle and with maximum cooperation, we would build a formidable force to lend our expertise and professional services to government, agencies, ministries, departments and individuals.
Looking back, I can say that last year was very eventful for us despite the global health challenge and looking ahead, I can see a more promising and brighter future for our dear association and Member Firms.

God helping us, all our initiated moves would yield positive results to the benefit of us all, we would win and execute contracts and we would make an indelible mark in the annals of history.
As we have launched into the New Year, let us stay ablaze with an unquenchable thirst for knowledge and professional development. To this end, I present to you the first edition of "The Consulting Engineer" magazine for the year 2021. This edition is designed to spark, rekindle and spur us to duty and diligence in the global response to resilient infrastructural development and engineering management.

*I wish you all a fruitful 2021 and a new year filled with lots of great accomplishments.*

***Engr. George C. Okoroma, FNSE, JP***
*President, ACEN*

# 2021 ACEN COUNCIL

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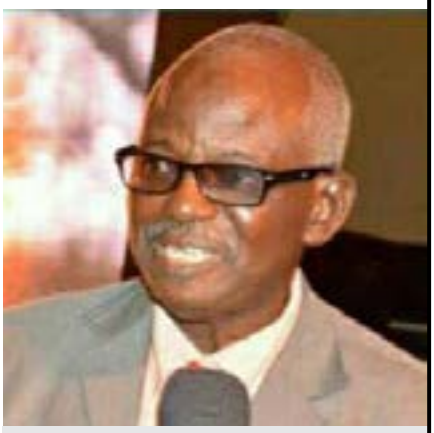

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# THE ASSOCIATION FOR CONSULTING ENGINEERING IN NIGERIA (ACEN)

The Association for Consulting Engineering in Nigeria, ACEN, was founded in 1972 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 was once Chairman of FIDIC Africa while several ACEN members served on the Executive Committee. The current ACEN President, Engr. George Okoroma, is a member 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 forty-one (41) 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.

# ALIGNING NIGERIAN CONSULTING ENGINEERS WITH BEST PRACTICES IN CORPORATE GOVERNANCE

BY ENGR. IBIKUNLE S. OGUNBAYO

***Engr. Ibikunle S. Ogunbayo,*** *FAEng, FNSE, CEng, (Chairman, KOA Consultants Limited)*

## 1.0 INTRODUCTION

A 'Consulting Engineering Firm' is a business entity and the requirements for its management must not be different from those required to run any other type of business organization. Many engineers, however believe, albeit wrongly, that only large companies with many shareholders need to be concerned about or can benefit from implementing corporate governance practices. This belief comes from the misconception that corporate governance ends with MBA classes and is theoretical without any perceptible influence either on efficiency or the company's profitability.

## 2.0 HISTORICAL PERSPECTIVE

According to the International Federation of Consulting Engineers (FIDIC), engineering consultants provide engineering-related services such as design, supervision, execution, repair, operation, maintenance, technology, creation of drawings and specifications and make recommendations to public and private companies, firms and industries. Engineering consulting firms require engineers from multiple disciplines including civil, structural, mechanical, electrical, environmental, chemical, industrial and agricultural in order to be able to cover the wide variety of potential projects that could be presented to the firm. The thrust of this definition is that the consulting engineer provides services to clients and will, of course, expect to be compensated for these services. It is expected that the engineer will only seek to provide services for which he or she has the training and the expertise to undertake. Consequently, a lot of premium is placed primarily on the professional training of the engineer, the experience that the engineer has garnered and the ability to satisfactorily deliver the services promised.

The engineering profession and the expectations of clients who employ the services of engineers are not new. The engineer was expected to demonstrate great skill and expertise and abide by set codes. The consequence of failure could sometimes be severe. One of the earliest recorded building codes was written by King Hammurabi of Babylon, Mesopotamia about 1754BC. These codes were only a part of the laws written by King Hammurabi.

Within the list of laws, the following sections were related to construction of buildings:

***228. If a builder builds a house for someone and completes it, he shall give him a fee of two shekels in money for each sar of surface.***

***229. If a builder builds a house for someone, and does not construct it properly and the house which he built falls in and kills its owner, then that builder shall be put to death.***

***230. If it kills the son of the owner, the son of that builder shall be put to death.***

***231. If it kills a slave of the owner, then he shall pay slave for slave to the owner of the house.***

***232. If it ruins goods, he shall make compensation for all that has been ruined and inasmuch as he did not construct properly this house which he built and it fell, he shall re-erect the house from his own means.***

***233. If a builder builds a house for someone, even though he has not yet completed it; if then the walls seem toppling, the builder must make the walls solid from his own means.***

Consultants in those days would have loved code number 228 but not so much the others. What these laws, however, demonstrated was the consequence of negligence in project delivery. The progression from Hammurabi's laws to modern day practices did not happen overnight. Practitioners in the built environment went from being skilled craftsmen, to master builders, to military engineers and these days to professionals, who had to undertake courses in their chosen areas of specialisation so that they could be called engineers or architects or any of the modern-day professional areas in the built environment.

As time went by, professional practitioners were being held accountable for the advice that they gave and were

held personally liable for whatever any adverse consequences occurred from such advice. To protect themselves, professionals formed associations and these associations produced codes of practice to guide the activities in each professional group. Such codes and guidelines, however, mainly dealt with the professional skills. As projects became larger and more complex, it became clear that holding individuals either jointly or severally liable for project delivery and consequential damages were becoming impractical. Consulting engineering firms needed to be larger and employ large numbers of staff but the principals were still liable for whatever mistakes were made by staff. Professional Indemnity Insurance could help but it was necessary to attempt to insulate the individual from the firm.

***"But one size does not fit every company and there is no uniform, comprehensive set of policies or practices."***

Clients' expectations continued to become more demanding. Managing large firms needed more managerial skills and the days when the sole practitioner could manage a firm in a loose and unstructured manner became unrealistic. Firms then became limited liability companies or partnerships and the needs of the shareholders also had to be considered. Firms had to become businesses and be managed as such and become more competitive and profit oriented, which is the primary reason for setting up any business. This is where the consulting engineers have been a bit lax and need to begin to sharpen the skills required to build not only businesses that return profit to the owners but also outlive the original owner(s). To compete in this modern world, all companies must establish and operate governance procedures that will enhance growth and profitability. Every firm, big or small, must compete in an environment where good corporate governance is a sensible business imperative.

## 3.0 CORPORATE GOVERNANCE BASICS

'Corporate governance' does not have a single accepted definition. The term broadly describes the processes, practices and structures through which a company manages its business and affairs and works to meet its financial, operational and strategic objectives and achieve long-term sustainability. The Business Dictionary defines 'Corporate Governance' as: The framework of rules and practices by which a Board of Directors ensures accountability, fairness and transparency in a company's relationship with all its stakeholders.

The corporate governance framework consists of:

***(1) explicit and implicit contracts between the company and the stakeholders for distribution of responsibilities, rights and rewards***
***(2) procedures for reconciling the, sometimes, conflicting interests of stakeholders in accordance with their duties, privileges and roles***
***(3) procedures for proper supervision, control and information flows to serve as a system of checks and balances. (FIDIC)***

This implies that engineering firms must be set up in such a manner that those who manage the business are fully aware of their legal and fiduciary responsibilities to shareholders, staff, lenders and all those who might have a stake in the wellbeing of the firm including government entities. The objective of corporate governance is to promote strong, viable and competitive corporations which are accountable to all stakeholders. But one size does not fit every company and there is no uniform, comprehensive set of policies or practices.

There are, however, several best practices that can help with the governance of any company. These include:

- There should be a strong, qualified Board of Directors: Boards should consist of directors who are knowledgeable and have expertise relevant to the business. They must be qualified .and competent. They should have strong ethics and integrity. The backgrounds should be diverse augmented by adequate skill sets. They need to commit sufficient time to their duties. No one Board member will have all the skills to manage a company and so the Board should be a mix of internal and external members who are able to provide the leadership required. They must all be trained so that the business of the company is fully understood.

- Roles and responsibilities should be clearly defined: Clear lines of accountability among the Board Chairman, Chief Executive Officer (CEO),

Executive Officers (EO) and management should be established. The Board and all committees of the Board should be given clearly written and agreed mandates. The roles of the Chairman of the Board, the CEO and all directors must be clearly defined. It is advisable to separate the positions of the Chairman and the CEO.

• Integrity and ethical dealing should be emphasized: A general culture of integrity in business dealing and compliance with the laws and policies without fear of recrimination is critical to the success of the company. Directors must declare potential areas of conflicts of interest.

• Parameters to assess Board performance should be established The Board should establish measurable performance targets for itself and executive officers (including the CEO), It must regularly assess and evaluate their performance and may even tie compensation to performances.

• There should be focus on effective risk management: Companies should regularly identify and assess the risks they face. These include financial, operational, reputational, environmental, industry-related and legal risks. The Board is responsible for strategic leadership and all directors must understand the emerging short and long term risks the company faces.

Effective corporate governance is the process by which a company polices itself. It is a method of governing the company like a sovereign state, stating its own customs, culture and policies to its employees from the highest to the lowest levels. Corporate governance is intended to increase the accountability of a company and to prevent massive disasters.

An engineering firm should be seen as a business entity that provides professional services and which, therefore, needs to operate as part of the corporate world. The methods of global business practices are becoming ever more demanding and the requirements for compliance with legal and statutory requirements are increasing day by day. Whereas corporate governance used to be seen as a voluntary matter, governments are now beginning to introduce rules that could be seen to be 'legally' binding. The Financial Reporting Council of Nigeria (FRCN) introduced guidelines entitled 'Regulation on the Adoption and Compliance with Nigerian Code of Corporate Governance 2018.' The new code, according to the FRCN, *"seeks to institutionalise corporate governance best practices in Nigerian companies... to promote public awareness of essential corporate values and ethical practices that will enhance the integrity of the business environment... rebuild public trust and confidence in the Nigerian economy, thus facilitating increased trade and investment."*

Most unregulated private companies, which will include most consulting firms, do not for now, need to comply with this code, but it would make good sense to begin the process of understanding its requirements and its implications. Sooner or later, compliance will be required.

A company that does not have in-house skills and processes to deal with such modern business requirements will find it difficult to survive not only in Nigeria but globally. These are the benefits to a company that is properly run under good corporate governance culture:

• Staff are exposed to good corporate governance practises which prepare them for future senior management roles

• Such a company lays the grounds for perpetual succession

• The company leadership understands the needs for compliance in an increasingly regulated environment

• With the right board structure, all cadres of staff have 'value for money' access to persons with varying skills.

The times are changing, and engineering consulting firms must not allow themselves to be left behind.

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2. *Code of King Hammurabi*
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4. *https://www.mcinnescooper.com/publications*
5. *Financial Reporting Council of Nigeria - Regulation on the Adoption and Compliance with Nigerian Code of Corporate Governance 2018*


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# PUBLIC PRIVATE PARTNERSHIP FRAMEWORK AND IMPLEMENTATION IN NIGERIA

**BY ENGR. CHIDI K. C. IZUWAH, BARR. JOE A. M. OHIANI & MR. FELIX O. OGBERA**

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## 1.0 INTRODUCTION

All over the world, the demand for infrastructure is outstripping supply and new strategies are being devised to address the deficit (African Development Bank, 2010). In Nigeria, the situation is not different. Decades of poor maintenance, underinvestment and near total neglect have left the country with an outrageous infrastructure deficit. Indeed, it has been widely acknowledged that one of the major binding constraints to Nigeria's economic growth and development is the excruciating shortage of infrastructure (National Planning Commission, 2015). The abysmal infrastructure deficit in Nigeria is, basically, the neglect by successive regimes to take proactive action to match the boom in our population growth over the years with corresponding development in infrastructure and allied services. It has been projected that Nigeria needs about US$100 billion to provide quality infrastructure for six years (Ibid).

Given this scenario and given the constraints on the public budget of financing the ever-growing infrastructure needs and in keeping with the practice in other nations with similar predicaments, the government has shifted part of the burden of infrastructure development and investment to the private sector as part of Public Private Partnerships (PPP) policy. PPP is a novel strategic approach which has been generally adopted in engineering management of public assets.

The current financial situation of Nigeria caused by the global COVID-19 pandemic and dwindling fortunes of oil has made this shift to PPPs more compelling than ever before. The philosophy behind this policy is to meet the challenge of developing and maintaining critical infrastructure by attracting massive private sector led investments beyond the means available to the government. Thus, in 2005, the Federal Government enacted the Act establishing the Infrastructure Concession Regulatory Commission (ICRC) to drive and regulate PPPs in Nigeria. The ICRC Act 2005 and the National Policy on Public Private Partnership constitute the principal legal and institutional frameworks for the operations and implementation of infrastructure PPPs in Nigeria. They clearly set out the requirements for competition and private sector participation as well as the specific responsibilities, approvals and implementation processes for all Federal PPP contracts in Nigeria.

## 2.0 WHAT ARE PUBLIC PRIVATE PARTNERSHIPS (PPPS)?

Simply put, a public private partnership (PPP) describes a government service or private business venture which is funded and operated through a partnership between a government and one or more private sector companies. From the legal perspective, PPP is a contractual arrangement between the government and a private company under which a private company finances, builds, operates and maintains public infrastructure or service; and the private company gets paid over a number of years, either through charges paid by users or by payments from the public authority, or a combination of both (Deloitte Research, Closing the Infrastructure Gap, 2006). In PPP arrangements, the private sector consortium typically forms a special company called special purpose vehicle (SPV) to develop, build, maintain and operate the infrastructure assets for the contracted period (Deloitte Research, Closing the Infrastructure Gap, 2006). Typically, the physical infrastructure where PPP projects are developed and managed include roads, bridges, power generation plants, power transmission/ distribution facilities, water/ sanitation networks, ports, airports, railways and grain storage silos.

The public partner is typically represented by the government at the national, state or local agency level. The private partner can be a privately-owned business or consortium of businesses with a specific area of expertise. These partnerships are commonly referred to as PPPs. In reference to the National Policy on Public Private Partnership of the Federal Government of Nigeria, a PPP is defined as a contract whereby the private sector is engaged by the public sector to manage some public services and to design, build, finance and operate some infrastructure to enhance efficiency, broaden access and improve the quality of public services. The role of the public sector is to plan and structure projects while the private sector directly implements the projects.

A PPP is structured in a manner that allows both the public and private sectors to enjoy certain advantages while performing their specific tasks. The government's contributions to a PPP may take the form of capital for investment, a transfer of assets, other commitments or in-kind contributions that support the partnership. The government also provides social responsibility, environmental awareness, local knowledge and the ability to mobilize political support. The private sector's role in the partnership is usually to make use of its expertise in commerce, management, operations and innovation to execute the project effectively and efficiently (Ibid). The private partner may also contribute investment capital depending on the form of the PPP contract.

## 3.0 KEY OBJECTIVES OF PPP

The objectives of a PPP are to increase the availability of infrastructure services and to do so with greater efficiency (lower cost for the level of services provided) than could be achieved using the traditional public sector approach. These objectives can be achieved because PPPs allow access to the substantial financial resources of the private sector. PPP also enables the public sector to benefit from private sector technical expertise, experience and efficiency. It enables the public sector to transfer project-related risks to the private sector.

In addition, a PPP brings the public and private sectors together as partners in a contractual agreement, often for a long period of about 15-30 years, which matches the life of the infrastructure assets used to provide the services. The private partners (investors, contractors and operators) undertake the implementation of the project, assume substantial risks associated with the project execution and provide specified infrastructure services. In return, the public sector either pays for those services as long as they are in line with the performance standards agreed or grants the private partner the right to generate revenue from the project. This allows the government to provide an improved quality of infrastructure services to the citizens in a cost-effective manner resulting from the efficiencies brought in by the private sector partner. It also allows the private sector partner to participate in large infrastructure projects, primarily in the public domain and generate the required returns from these projects.

## 4.0 GENERAL PPP FRAMEWORK AND ITS PRINCIPLES

A PPP framework is a combination of policies and laws that define how and when PPPs can be used to deliver public services. It includes the institutional responsibilities, rules and procedures for developing and implementing PPPs. Indeed, a good PPP framework ensures that the right projects are selected as PPPs, developed, delivered and managed in a structured, transparent and efficient way. It equally minimises the risks that a PPP project will not deliver value for money (APMG, 2016).

PPP frameworks also aim to improve the execution of PPP projects. The institutional responsibilities, rules and procedures are designed to ensure that PPPs are well-structured with risks allocated appropriately. They are procured at minimum cost by ensuring that the procurements are competitive and attract as many bidders as possible. PPP projects are structured up-front so as provide relevant information to potential bidders (National Policy on Public Private Partnership, 2009). The framework ensures that the PPPs are developed and implemented efficiently by reducing the complexity of coordination between government agencies. The aim is to achieve the appropriate balance between in-house expertise and the expertise of external advisors.

To achieve these aims, the government needs to play a leading role throughout the process of developing and implementing each PPP. There are four main stages of PPP development and implementation in the PPP process in Nigeria. In line with the National Policy on Public Private Partnerships, the PPP project life-cycle in Nigeria consists of project development, projectprocurement, project implementation and project maturity (Ibid). Each stage has specific activities that are aligned with

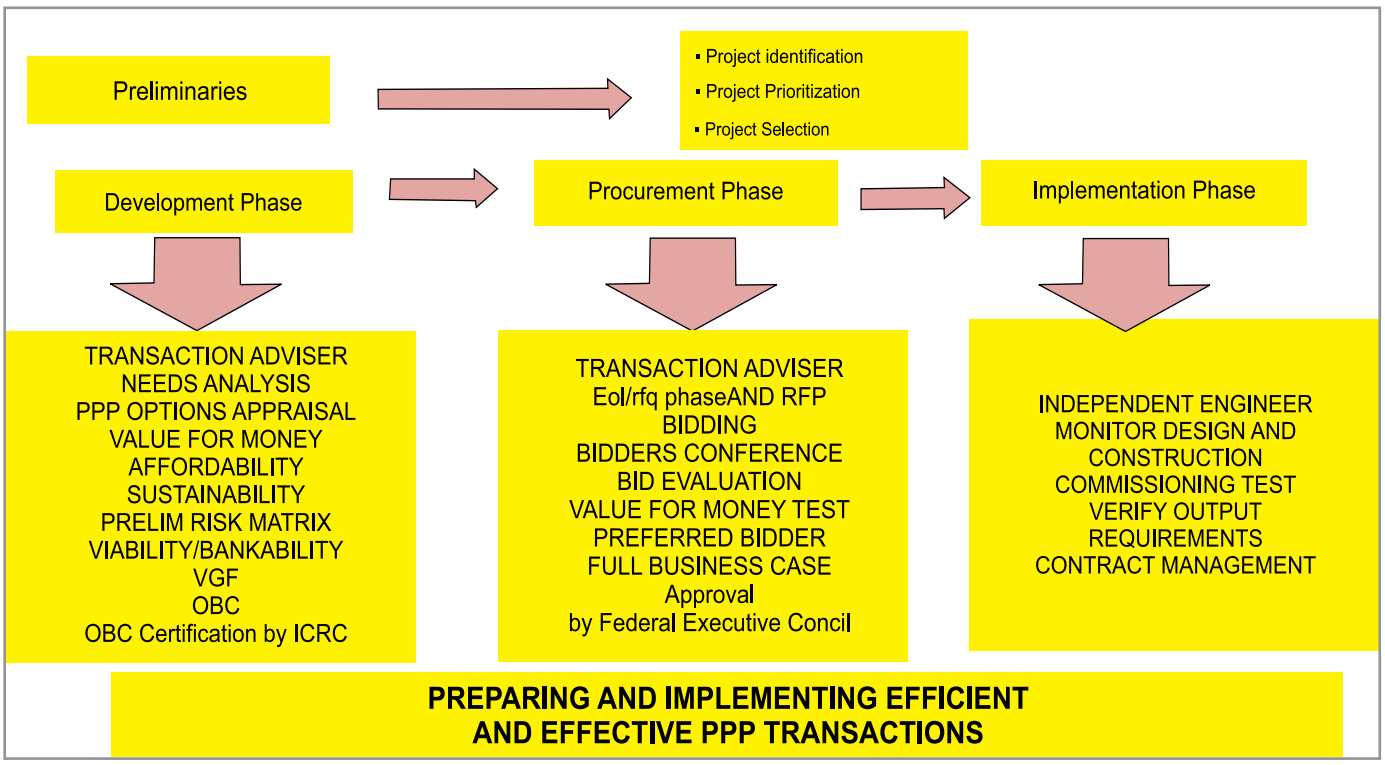


**Fig 1:** *PPP lifecycle in line with the national policy.* *Source: Infrastructure Concession Regulatory Commission*

the objectives of the framework, summarize the functions the government should perform and identifies the policies, responsibilities, rules and procedures that need to be defined to ensure the government is performing its functions *(See Fig. 1)*.

The essence of the PPP framework is to provide for transparent, efficient and competitive procurement procedures for PPP contracts that encourage innovation from bidders. It allows dialogue to optimise the allocation of risks between the contracting parties (National Policy on Public Private Partnership, 2009). It also ensures that there is an effective dispute resolution process which can operate independently and in a timely manner to provide alternative procedures such as arbitration and expert determination. Together, these policies, responsibilities, rules and procedures form the Nigeria PPP framework which is in tandem with global best practices.

## 5.0 PPP FRAMEWORK AND IMPLEMENTATION IN NIGERIA

The Nigeria PPP framework defines and places emphasis on how projects will be implemented to ensure good governance of the PPP tool, that is to promote efficiency, accountability, transparency, decency, fairness and to generate private sector interest and public acceptance of PPPs (National Policy on Public Private Partnership, 2009). The framework standardizes the processes and documents which will save time and effort in the preparation and implementation of PPP tasks which are extraordinarily demanding. The existence of a proper and strong governance approach ensures a stable, comprehensive and durable PPP framework.

It is also necessary to homogenize the PPP processes to ensure that the tasks, procedures and conditions for procuring and implementing PPPs are met and clearly understood by the public and private sectors participants (National Policy on Public Private Partnership, 2009). This will assist in attracting and retaining the interest of the private sector in PPPs. However, the PPP framework must be underpinned by official documents in the form of policies, regulations, guidelines and responsibilities that bind the participants who will operate under the framework.

The approach chosen by a country for PPP framework documentation depends on two factors: the legal system or legal tradition of the country (with the main difference consisting of countries with common law systems versus countries with civil code traditions) and the degree of development in terms of PPP experience and use (APMG, 2016) No doubt, the increasing complexities in PPP projects coupled with governance exigencies have

made it paramount for the procurement process to be carried out in a fair and transparent manner. To ensure that these procurements are made by following a uniform, systematic, efficient and cost-effective procedure and to ensure a fair and equitable treatment of service providers, there are statutory provisions, manuals, guidelines etc. on the subject of PPP procurement which provide the framework for implementation in Nigeria. PPP procurement processes in Nigeria are governed by the Infrastructure Concession Regulatory Commission (Establishment, etc) Act 2005, the Public Procurement Act, 2007, the National Policy on Public Private Partnership, Nigeria (N4P), other subsequent regulations, guidelines and circulars on the subject. They clearly define the roles and responsibilities of the ICRC, key PPP stakeholders including Ministries, Departments and Agencies (MDAs) of the Federal government and the private sector.

The ICRC provides the regulatory and institutional framework for MDAs to, in effect, partner with the private sector for infrastructure projects as provided for in the ICRC Act, 2005. However, only federal entities undertaking federal projects fall under the scope of the ICRC Act. State government entities and state infrastructure projects are not regulated by the ICRC. States may develop their own frameworks for PPPs and a number of them have made great progress in this regard. Although each state is responsible for its own investment projects, its projects may be financed with the support of a guarantee by the federal government, considering the fact that various agencies, such as the World Bank, work through the federal government.

The National Policy on PPP sets out the government objectives and commitments with regards to PPP as well as key principles of PPPs in the Nigerian context. In addition, it outlines government's role in the creation of an enabling environment and the processes in the PPP project lifecycle. These, in addition to the ICRC Act and other guidelines, provide the framework for implementation of PPPs in Nigeria. The National Policy on PPP clearly outlines the roles of MDAs and other stakeholders in the PPP ecosystem in Nigeria. In addition, the policy emphasizes the value for money, competition, risk allocation, public interest, transparency and capacity to deliver in accordance with the key principles governing PPP procurement in Nigeria. It was developed to provide clear and consistent process, procedure and guidelines for all aspects of PPP projects development and implementation. The National Policy on PPP was approved by the Federal Executive Council (FEC) in April 2009. The process for procuring PPPs by the MDAs is expected to be designed and implemented in compliance with these principles of procurement. The MDAs and their staff are responsible and accountable for complying with the process and practice of project initiation and development, project approval, determination of output requirements and ensuring the execution of the contract. The underlying principle in Nigerian PPP transactions is that risks are allocated to the party best able to manage them. All these activities are subject to ICRC's regulation and the approval of the Federal Executive Council (FEC).

On the other hand, the ICRC has the statutory powers to issue policy, guidelines, regulations and enhance capacity building as well as evaluate the bankability of PPP projects. Also, the ICRC is charged with the responsibility of developing a robust PPP market, assess and evaluate value for money and risk management regime. In addition, the Commission has the mandate to facilitate, regulate and assist MDAs develop bankable PPP projects, as well as take custody and ensure the parties' compliance with the terms and conditions of PPP agreements (The ICRC Act, 2005). The PPP procurement process involves open and transparent tendering, evaluation of request for proposals (RFPs), negotiation and contract signing while project implementation involves design, construction, operation, monitoring, contract management and evaluation.

***"The National Policy on PPP sets out the government objectives and commitments with regards to PPP as well as key principles of PPPs in the Nigerian context".***

## 6.0 SOME PPP PROJECTS

Figs 2, 3, 4, 5, 6 and 7 show some ongoing projects being executed under PPP arrangement within ICRC regulatory framework.

**Fig. 2:** *Calabar Port Terminal*

**Fig. 3:** *Guarara Hydro Power Project*

**Fig. 4:** *Ibom Deep Water Port*

**Fig. 5:** *National Theater, Iganmu, Lagos*

**Fig. 7:** *Zobe Hydro Dam, Kaduna*

**Fig. 6:** *Tincan Island Multi-Services Container Terminal*

## 7.0 THE IMPERATIVE OF PPPS IN NIGERIA

In order to bridge the growing gap between the cost of infrastructure needed and resources available and to ensure that the infrastructure is delivered as efficiently and cost-effectively as possible, it has been realized globally that effective public and private sectors collaboration remains the key driver of

economic activities for nations desiring true and positive infrastructure development (The World Bank, PPP Units, 2007). No doubt, PPPs are a growing element of public sectorprocurement globally. Consequently, the wide infrastructure gap in Nigeria coupled with depleting government resources and the urgent need for alternative funding has led to the growing demand for private sectorparticipation ininfrastructure development through PPPs.

It should be noted that PPP procurement is one of several options of procuring infrastructure. However, there should be consideration as to whether a project is suited for a PPP structure and whether there is a strong political support for a PPP solution. The principal reason for using a PPP option is that it can deliver better value for money than the alternatives. Indeed, there is evidence that the more comprehensive and institutionalized the PPP framework, the greater the chance of success of the PPP projects in delivering value for money (APMG, 2016). Besides, another compelling reason for the PPP option is that PPP schemes combine the best capabilities of public and private sectors for mutual benefits including the enhancement of the growth of the economy.

## 8.0 SOME BENEFITS OF PPPS

The benefits of a successful PPP to a country are huge. A successful PPP sets the tone for future PPPs, boost investors' confidence and the government's international credibility. PPPs, undoubtedly, provide opportunities to improve service delivery by allowing the public and private sectors to do what they know how to do best. Government's core business is to set policy and serve the public. It is better positioned to do that when the private sector takes responsibility for some critical functions such as financing, constructing, operating and maintaining the infrastructure. PPPs also improve cost-effectiveness by taking advantage of private sector innovation, experience and flexibility. PPPs can often deliver services more cost-effectively than traditional approaches, resulting in savings which can then be used by government to fund other needed services. PPPs can also improve budget certainty as well as better use of assets. The private sector partners are motivated to use facilities fully and make the most of the commercial opportunities to maximise returns on their investments.

No doubt, Nigeria is in dire need of efficient public infrastructure and services as its infrastructure gap is adversely impacting the full potential of its economic growth and development. Studies have revealed that the total amount of funds required by the government to provide quality infrastructure in Nigeria for six years is about $100 billion (National Planning Commission, NIIMP, 2015). However, considering the limited resources at the disposal of the federal government, vis-a-vis competing needs, the country must explore viable alternative sources of funding infrastructure provisions in the economy in order to achieve the objectives of national infrastructure development as clearly articulated in the Federal Government's Economic Recovery and Growth Plan (ERGP). It is clear in ICRC that PPP serves as a leverage to give Nigeria world class roads, ports, hospitals, educational institutions and other critical infrastructure facilities and services needed to boost the economy.

## 9.0 SUCCESSES AND CHALLENGES OF PPPS IN NIGERIA

In Nigeria, like many other countries, PPP is appreciated as an important procurement option for infrastructure development. Though there have been successes in institutional and regulatory framework, other critical issues like transaction expertise and PPP financing facilities are yet to be boosted in the country. There is also the need to have a strong incentive for the executing agencies that will bring more bankable PPP projects for the private sector. The ICRC is doing so much within its limited resources to also sensitize and create the needed awareness on the viability of the PPP option as infrastructure procurement alternative. In spite of the obvious challenges, records revealed that as at October 30, 2020 there were 73 post-contract PPP projects under implementation at the ICRC Projects Disclosure Portal (www.ppp.icrc.gov.ng or www.icrc.gov.ng).

As at November 25, 2020, there were 153 pre-contract projects at development and procurement phases at the ICRC website (www.icrc.gov.ng). Also, between 2010 and 2020, under the regulatory guidance of the ICRC, the Nigerian Government approved PPP projects worth over US$8 billion. This amount represents expected private capital investment in the provision of public infrastructure across

various sectors of the economy. Many projects are also in the pipeline. Similarly, as at the end of October 2020, the Commission has granted 14 Outline Business Case (OBC) and 8 Full Business Case (FBC) Compliance Certificates, bringing the total compliance certificates granted since inception of ICRC to 90 OBC and 40 FBC certificates. In spite of the appreciable successes recorded so far by the Commission, challenges still exist. They include:

### 9.1 LACK OF SUFFICIENT GOVERNMENT FUNDS

Infrastructure, as we are aware, remains a catalyst for socio-economic growth and development, especially for emerging markets and developing economies like Nigeria. Unfortunately, the magnitude of resources required to turn around infrastructure in Africa cannot be afforded by any single government. In Nigeria, infrastructure development has been largely funded from the fiscal budgets, which are highly volatile, inadequate and often receive a larger brunt of fiscal retrenchment in times of financial crises, in addition to its exposure to potential mismanagement and corrupt practices (National Planning Commission, NIIMP, 2015). The national fiscal budget has been the principal source of financing infrastructure development in Nigeria; hence it has become a yearly ritual to wait for capital infusion through the fiscal budget to rehabilitate, repair or replace dilapidated assets, rather than maintain the infrastructure (Ibid).

Obviously, PPPs can make a significant difference in the quest for infrastructure growth in Nigeria like other countries across the world, because of its potential to unlock more finances, expertise and efficiency. This explains why public sector collaboration with the private sector in the funding of infrastructure in Nigeria cannot be wished away. The National Integrated Infrastructure Master Plan (NIIMP) document expects PPPs to play a significant role as one of the critical sources of financing to address critical infrastructural gaps in the country.

### 9.2 LACK OF CAPACITY AND TRANSACTION KNOW-HOW IN MDAS

First, getting the MDAs and the private sector partners to abide by the PPP Policy Guidelines has been a challenge. In collaboration with the Offices of the Secretary to the Government of Federation, Head of the Civil Service of the Federation, Federal Ministry of Finance, Budget and National Planning, the Commission is championing the establishment of PPP Units and building the capacity of MDAs especially in the areas of project development, tendering, negotiation and contract execution. Conceptually, these PPP Units will become and remain the reservoir of institutional knowledge and expertise for PPPs in the MDAs.

As part of efforts to strengthen and enhance the capacity of MDAs and other stakeholders on infrastructure and PPP, ICRC established the Nigeria Institute of Infrastructure and Public Private Partnership (NII3P) in 2019. The Institute has since commenced operations with the successful take-off of 15 virtual and physical training programs so far. It has also launched a 3-semester Masters in Business Administration degree (MBA) programme in PPP in collaboration with the Malaysian University of Science and Technology. So far, the ICRC has undertaken PPP capacity building for over 3,000 federal government officials as part of its mandate to develop the Nigerian PPP market with skilled manpower.

### 9.3 INSUFFICIENT PUBLIC ACCEPTANCE OF PPP AS A CRITICAL ALTERNATIVE TO INFRASTRUCTURE PROVISION

This is borne out of limited understanding of the numerous advantages of the PPP model as a way out of the present infrastructure dearth. However, conscious of this challenge, the ICRC is intensifying efforts to continuously sensitize, enlighten and educate government officials, policy makers and members of the public at every opportunity on the huge benefits of PPPs to help reduce resistance and the efforts have started yielding fruitful results.

***"The identification of critical success factors for a PPP transaction to survive and flourish constitutes the first important step towards the development of a workable and efficient PPP procurement process".***

*"Affected employees, the portions of the public receiving the service, the press, appropriate labour unions, the community and relevant interest groups will all have opinions and frequently significant misconceptions about a partnership and its value"*

### 9.4 POLITICAL AND POLICY ENVIRONMENT

The ICRC has done tremendous work to build up confidence within the community of investors locally and internationally. In 2017, the ICRC partnered with the World Bank Group to launch the first ever PPP Contract Disclosure Web Portal in the world meant to disclose PPP transactions at all levels as they progress.

The Web Portal serves to assure investors of the government's stand on transparency in procurement and management of public assets procured through PPP. Political and policy environment is of great importance to PPP infrastructure because no investor will be willing to invest its capital if the returns on investment do not provide sufficient compensation for the perceived level of risks inherent in a particular market (Deloitte Research, Closing the Infrastructure Gap, 2006).

## 10.0 CRITICAL SUCCESS FACTORS FOR PPP IMPLEMENTATION IN NIGERIA

The identification of critical success factors for a PPP transaction to survive and flourish constitutes the first important step towards the development of a workable and efficient PPP procurement process. Such critical success factors include:

### 10.1 APPROPRIATE PROJECT TEAM COMPOSITION

Decision makers should form part of the project team right from the start of the project. The results should be measurable so that the progress of the project can be monitored. The project should be goal-directed and focus on results. There should be an independent project team and an independent project leader, who reports to a steering committee consisting of top representatives from both the public and private sectors. A concessionaire should be appropriately selected. There should be adequate and clear working methods and agreements as well as an appropriate risk allocation between the public and private partners in the PPP arrangement. Mutual confidence should exist between the partners backed by a sound financial package.

### 10.2 UNDERSTANDING GOVERNMENT ROLES AND RESPONSIBILITIES

The main roles of the government include:

- To create a favourable investment environment
- To establish an adequate legal/regulatory framework
- To establish a coordinating and supportive authority
- To select a suitable concessionaire and
- To be actively involved in project life-cycle phases
- To ensure that the project meets its quality and delivery objectives

For emphasis, the establishment of a sound regulatory framework is a pre-requisite for successful PPPs (The World Bank, PPP Units, 2007).

### 10. 3 DEVELOPMENT OF A DETAILED BUSINESS PLAN

Partners must know what to expect in the partnership beforehand. A carefully developed plan (often done with the assistance of an expert in this field) will substantially increase the probability of success of the partnership. This plan, most often, will take the form of an extensive, detailed contract, clearly describing the responsibilities of both the public and private partners (The World Bank, PPP Units, 2007). In addition to attempting to foresee areas of respective responsibilities, a good plan or contract will include a clearly defined method of dispute resolution because not all contingencies can be foreseen.

### 10.4 SELECTION OF A SUITABLE CONCESSIONAIRE

The success of a PPP project depends largely on the selection of the most suitable private concessionaire. This requires a well- structured tendering process, an appropriate concessionaire evaluation method, and a set of transparent evaluation criteria (Ibid).

### 10.5 GUARANTEED REVENUE STREAM

While the private partner may provide the initial financing for design, construction and other improvements, there must be a means of repayment of this investment over the long term of the partnership. The income stream can be generated by a variety and combination of sources (fees, tolls, shadow tolls, tax increment financing or a wide range of additional options), but must be assured for the length of the partnership.

### 10.6 STAKEHOLDER SUPPORT

More people will be affected by a partnership than just the public officials and the private-sector partner. Affected employees, the portions of the public receiving the service, the press, appropriate labour unions, the community and relevant interest groups will all have opinions and frequently significant misconceptions about a partnership and its value to the public. It is important to communicate openly and candidly with these stakeholders to minimize potential resistance to establishing the partnership.

## 11.0 CONCLUSION

Leveraging on the PPP option is imperative considering the amount of resources needed to upgrade public infrastructure in the country. Clearly, the provision of infrastructure is not a matter for the public sector alone with its limited finances and entrepreneurial skills. It is also not a task to be undertaken by the private sector on its own. The reality is that the private sector has limited capacity to influence policy, enact laws and regulate markets. In short, only through a combined effort - a public private partnership - can the infrastructure challenge be significantly overcome. The regulatory capacity of the ICRC must also be strengthened to enable it effectively deliver on its mandate.

Nigeria has the advantage of scale. It has a population of over 180 million people, almost 1/5 of Africa's population. Nigeria also has an abundant supply of natural resources with the benefit of geography, being located in the centre of Africa with huge regional markets. Obviously, Nigeria is the biggest infrastructure market on the African continent. The future is bright if stakeholders in both public and private sectors can synergize efforts to reap the enormous benefits of PPPs in the interest of Nigerians and Nigeria.

***"The success of a PPP project depends largely on the selection of the most suitable private concessionaire. This requires a well-structured tendering process, an appropriate concessionaire evaluation method and a set of transparent evaluation criteria (Ibid)."***

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# ENGINEERING MANAGEMENT IN CONSTRUCTION OF DAMS

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## ABSTRACT

*Engineering management practice has gathered tremendous momentum in the last decade. The scale of infrastructural development has given rise to major projects being completed and put into use in many developed countries. It has equally brought new issues and challenges to engineering management practice. This paper seeks to address how engineering management may be applied specifically in dam construction with the objective of eliminating waste of time, money, materials so as to enhance sustainability of the project, etc and consequently address the issues of functionality, safety and economy.*

**Key words: Dam Planning, Construction, Management, Instrumentation, Safety and Economy**

## 1.0 INTRODUCTION

Wikipedia describes 'Engineering Management' as a career that brings together the technological problem-solving ability of engineering and the organizational, administrative and planning abilities of management in order to oversee the operational performance of complex engineering driven enterprises.

Engineering management and judgment involve the following areas of attention:

- Responsibilities of employees
- Choices amongst physical feasible alternatives
- Economic and financial feasibility of the project
- Social acceptability of projects
- Community participation and public involvement
- Risks associated with project execution
- Management techniques

These key areas apply to various projects with dam construction projects inclusive. In particular, issues of economy, safety and effectiveness must be emphasized in dam projects. Dam engineering management specifically requires full understanding of the enormous impact and potential energy of water with the dam foundation through geotechnical, hydrological, hydraulic, mechanical and structural design as major components.

## 2.0 CORE BENEFITS OF DAMS

### 2.1 GENERAL

If a dam project is to be constructed, the intention generally is to improve the standard of living of the citizenry. For instance, access to electricity, safe drinking water, irrigation, ecological and environmental protection, employment, tourism, trade and investment, rural development and poverty reduction constitute core major benefits. To implement this project, management issues will include amongst others, choice of technology, definition of work tasks, financial involvement and duration.

### 2.2 HOW DAM CONSTRUCTION ENHANCES SOCIO-ECONOMIC DEVELOPMENT

There is a correlation between the per capita storage capacity and human development index (HDI) as described below:

I. The development of dams, particularly with hydropower component, is closely related to socio-economic development.

II. To better demonstrate their coherence, the correlation between the United Nations Human Development Index (HDI) and the capita storage capacity or the degree of development of the economic dam/hydropower potential was studied based on the data for about 100 countries (UN 2011, World Atlas and Industry Guide 2011).

III. To consolidate the HDI issue raised above, Berga (2008) compares the average values of the per capita storage capacity in different countries with the HDI, (See Fig. 1).

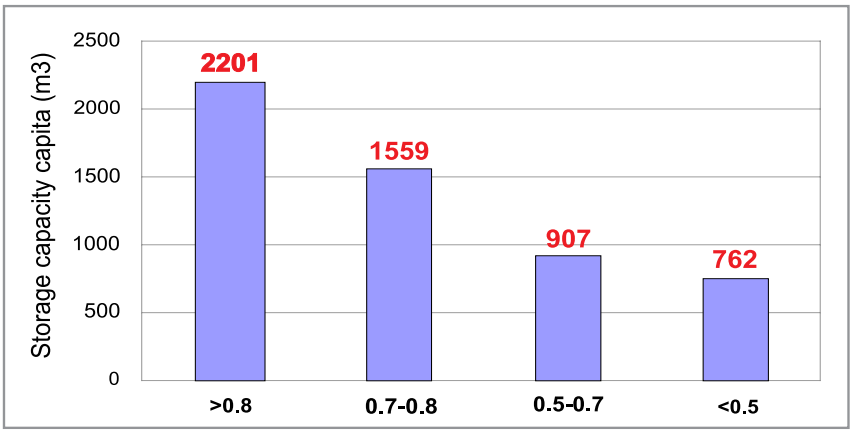


**Fig. 1:** *Human Development Index (HDI)*

It is indicated that developed countries have a solid ground for securing water safety, but developing countries still face challenging limitations in financial, technical and human resource capabilities. HDI figures for developing countries fall below 0.7 and some below 0.5. Examples in Africa are Mozambique, Nigeria and Egypt with Egypt having HDI of 0.64. In general, the level of dam development in a country is closely consistent with the level of human development.

## 3.0 PLANNING PROCESS IN A DAM PROJECT

In the initial planning stages, there is need to identify problems and opportunities as well as consider alternative sites where necessary. The planners, economists and engineers working together need to arrive on an acceptable best decision. The result is the flow chart shown in Table 1.

Like a detective, a planner begins with a result (i.e a facility design) and must synthesize the steps required to yield this result for effective engineering management. The best decision will affect the location and choice of dam type, either earth, concrete or rockfill or in some cases roller compacted concrete dams. The essential aspects of construction planning include the generation of activities stated above, analysis of the implications of these activities and choice among the various alternative means of performing these activities.

## 4.0 DAM CONSTRUCTION

### 4.1 SIMPLE ENGINEERING STEPS

The simple engineering steps comprise:

I. Relocation of highways, roads, gas and electric utility lines and communities as deemed fit
II. Preparation of site, clearing of trees, vegetation and buildings
III. Diversion of river bed to enable the foundation to be excavated and the concrete, earth or rock placed
IV. Diversion of the flow of river from the area (Frequently half of the riverbed is excavated at one time, the other half of the riverbed is unaltered)
V. Building small cover dams upstream to divert the river into a tunnel or some gates
VI. Operating the gates for the tunnel in line with the design objectives of the dam
VII. Bringing the entire dam to full height in the final part of the construction period
VIII. Installing the turbine followed by release of water and connecting the turbine through a shaft to the power house (If the dam has a hydropower component)
IX. Installing other water conveyance structures which include a spillway, tailrace channel, stilling basin, power house and sluiceway.

### 4.2 DAM CONSTRUCTION MACHINERY

Many people wonder how dams are constructed on the rivers. It is an interesting engineering endeavour but made possible with technology using heavy/ light construction equipment, (See Figs. 2 and 3). Dams are key aspects of an infrastructure. They conserve and store water which is further utilized for agricultural and industrial purposes. Both heavy and light machineries are required in the production of electricity and water supply for the construction of dams. Some types of dam construction machines include:

- **Back hoe loader**
- **Bulldozer with blade**
- **Bulldozer with hydraulic scrapper**
- **Sheepsfoot roller, crusher loader, etc**

Well thought outengineering techniqueis adopted in dam construction. Without the support of heavy construction equipment,it would be difficult for the engineers to construct huge damprojects, e.g Hoover dam, Kainji dam, etc that hold such a huge amounts of water pressure.

### 4.3 DAM INSTRUMENTATION

Instrumentation and monitoring are necessary in the reservoir, the appurtenant structure and the river basin for normal operation and safety. Monitoring

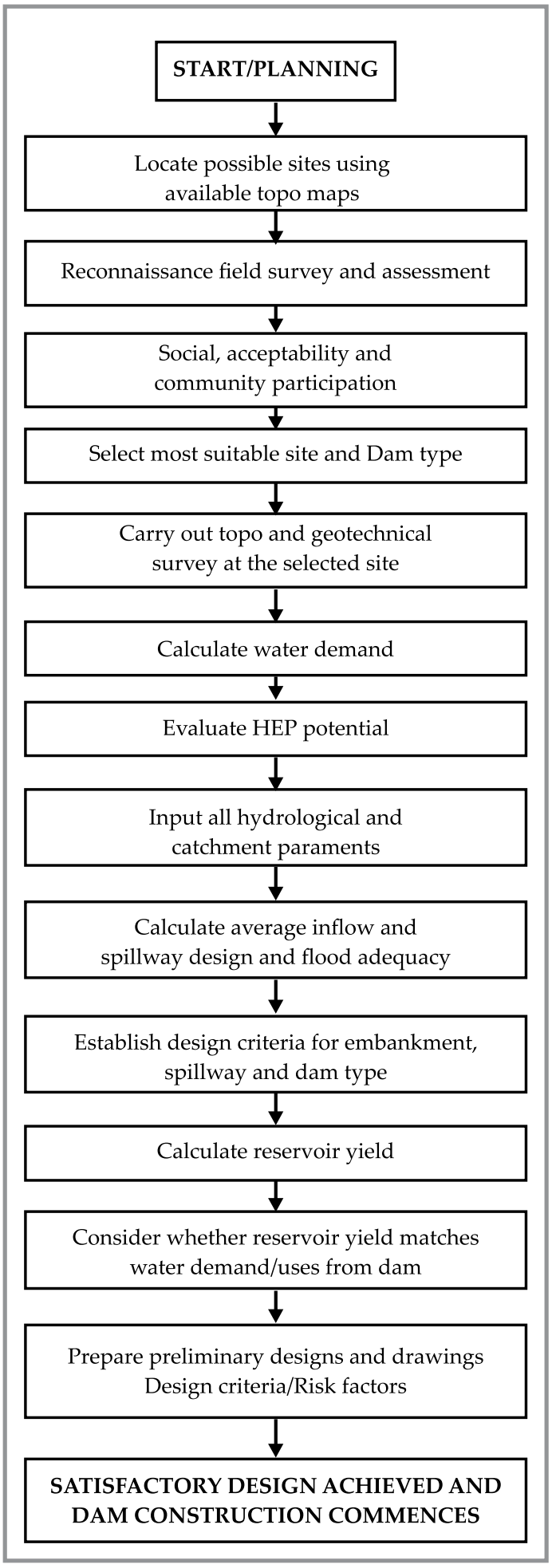


**Table 1:** *Flow chart for effective engineering management in dam construction*

has a variety of uses during the life of a dam from the investigation during design, construction and operation phases. This is an efficient engineering management practice. The methods and equipment used depend on the types of dam and the desired accuracy. Types of instrumentation vary for concrete dams, to embankment dams, water level and water quality investigation and the relevant engineering concepts, e.g differences between water levels upstream and downstream and factors influencing pressure distribution. Table 2 shows the frequency guidelines for reading various instrumentation systems.

## 5.0 MAJOR CONCERNS FOR FUTURE ENGINEERING MANAGEMENT OF DAMS

The major concerns include:

**Fig. 2:** *Heavy dam construction equipment*

**Fig. 3:** *Concrete batching plant*

### 5.1 SAFETY

There should be concerns about safety of dams against extreme natural disasters. Dams should not be constructed at locations prone to natural disasters. Further to this note of caution, there is need for dam safety regulation to promote safety as well as social acceptance of dam projects.

### 5.2 CLIMATE CHANGE

There is need for engineers who are managing dams to be conscious of changes in hydrological patterns and the effects on reservoir operation due to the impact of climate change. These issues need to be addressed in dam management.

### 5.3 QUALITY OF DECISIONS IN DAM CONSTRUC-TION

Decisions concerning dam construction should be based on economic justification, technical feasibility, social acceptability, environmental friendliness and safety.

### 5.4 OPERATIONAL MANAGEMENT

Concerns on operational management should cover areas such as:

- Ensuring functionality of the dams to meet the objectives of the project
- Ensuring engineering safety and ecological safety,
- Benefit sharing to cover national interest and the interest/demands of affected persons through the payment of ecological compensation, promotion of social harmony and sustainable development.

### 5.5 LEGISLATIVE ISSUES

Water Act should be enacted to improve on standardization and dam safety control.

## 6.0 CONCLUSION

The role of dams is fundamental in the world of the future. That will be characterized by urbanization, modernization and increasing concerns of climate change. However, the thrust of this paper is on proper planning, adaptive engineering design, innovative construction technology and safety monitoring of instruments and improvement of socio-economic living.

***According to John Fowler:***

***"Engineers are not mere technicians and should not approve or lend their name to any project that does not promise to be beneficial to man and the advancement of civilization."***

| S | Instrument type | Construction | During 1st filling | 1st Year | Regular |
|---|---|---|---|---|---|
| 1 | Pneumatic piezometers | Twice monthly | Twice weekly | Monthly | Monthly |
| 2 | Vibrating-wire piezometers | Twice monthly | Twice weekly | Monthly | Monthly |
| 3 | Total pressure cells (vibrating-wire, pneumatic, other) | Monthly | Weekly | Monthly | Quarterly |
| 4 | Porous tube piezometers | Twice weekly | Twice weekly | Monthly | Monthly |
| 5 | Slotted pipe piezometers | Twice monthly | Twice weekly | Monthly | Monthly |
| 6 | Observation wells | Twice monthly | Twice weekly | Monthly | Monthly |
| 7 | Seepage measurement devices (weirs, flumes etc) | Monthly | 3 times a week | Monthly | Monthly |
| 8 | Geophysical seepage measurements | As required | As required | As required | As required |
| 9 | Internal vertical movement devices | Complete set of reading each time a unit is installed | Monthly | 6 months after completion | 6 years interval |
| 10 | Foundation baseplate settlement | Complete set of reading each time a unit is installed | Monthly | 6 months after completion | Annually |
| 11 | Pneumatic settlement sensors | Monthly | Monthly | 1 month after completion | Annually |
| 12 | Vibrating-wire settlement sensors | Monthly | Monthly | 1 month after completion | Annually |
| 13 | Inclinometers (horizontal and vertical movements) | Complete set of readings each time an extension is added | Monthly | Monthly | Annually or semi annually |
| 14 | Shear strips | Monthly | Monthly | 3 months after completion | Annually |
| 15 | Tiltmeters | Monthly | Monthly | 3 months after completion | Quarterly |
| 16 | Embarkment measurements points | At time of installation | At 3 months intervals normally, but sometimes monthly | 6 months after completion | 3 to 6 years intervals |
| 17 | Vibration measurement devices | As construction progresses if blasting is conducted | Monthly | 6 months after completion | 3 to 6 years intervals |
| 18 | Water quality testing | Monthly (if required) | Monthly (if required) | Monthly (if required) | Monthly (if required) |

**Table 2:** *Frequency guidelines for reading various instrumentation system*

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## BRIEF PROFILE

**SAMABOT & ASSOCIATES LTD** is an indigenous multi-disciplinary engineering consultancy company registered in 1998 under the Companies and Allied Matters Decree 1990 with registration number BN 960347 and became a limited liability company in 2010 with RC 882478.

The company specializes in the provision of comprehensive engineering consultancy services covering:

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- Nigerian Content Development and Monitoring Board (NCDMB) Head Office, Bayelsa State
- Petroleum Technology Development Fund (PTDF) Headquarters Building, Abuja
- National College of Petroleum Studies (NCPS), Kaduna
- Central Bank Nigeria (CBN) Intervention Project: Centre of Excellence, University of Lagos
- CBN Hospital, 8, Tinubu street, Lagos
- CBN Intervention Project for Administrative Staff College of Nigeria,Badagry
- Dutse Airport, Jigawa State
- Jos University Teaching Hospital, Lamingo Jos
- Federal University of Technology, Minna

# PROJECT PICTURES

*PTDF Head Office Building, Abuja*

*Fire pumps installed at PTDF Head Office, Abuja*

*Generators installed at PTDF Head Office, Abuja*

*Pumps installed at PTDF Head Office, Abuja*

*Air handling units installed at PTDF Head Office, Abuja*

*Chillers installed at PTDF Head Office, Abuja*

*Generators installed at NCDMB Head Office, Bayelsa State*

*NCDMB Head Office Building, Bayelsa State*

*Chillers installed at NCDMB Head Office, Bayelsa State*

# PROJECT PICTURES

*Dutse Airport, Dutse*

*CBN Hospital, Lagos*

*National College of Petroleum Studies, Kaduna*

*Jos University Teaching Hospital, Jos*

*Auditorium of Administrative Staff College of Nigeria, Badagry*

# MANAGEMENT TEAM

**Engr. Sam Otenaike, FNSE, FIMC**
**(CEO/Principal Partner)**

**Engr. Gbenga Onifade, MNSE, MCIBSE**
**(Director of Projects)**

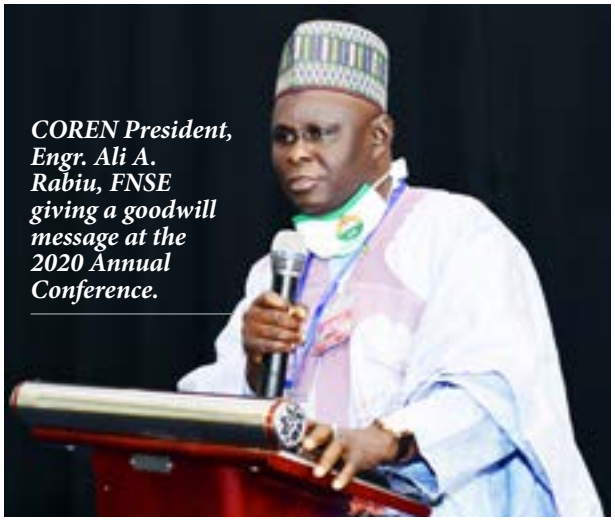
# ACEN ACTIVITES IN PICTURES

## ACEN AGM: 4TH - 5TH NOVEMBER 2020

*ACEN President, Engr. George C. Okoroma FNSE, JP giving his welcome speech at the 2020 Annual Conference held in Abuja.*

*Managing Director, Federal Roads Maintenance Agency (FERMA) - Engr. Nurudeen Rafindadi, FNSE, FAEng delivering the keynote address at the 2020 Annual Conference.*

*Group photograph with the Honourable Minister of Water Resources, Engr. Suleiman Adamu, FNSE, FAEng (middle) who represented the Vice President of the Federal Republic of Nigeria, Prof. Yemi Osinbajo SAN, GCON as Special Guest of Honour and who was a Keynote Speaker at the event. (L – R): ACEN President, Engr. George C. Okoroma, FNSE, JP (immediate left); Senator Iyiola Omisore, FNSE, CON (2nd left); ACEN Vice President, Engr. Ajibade F. Oke, FNSE (immediate right); ACEN Immediate Past President, Engr. Charles 'Yele Akindayomi, FNSE (2nd right) and other esteemed members of ACEN.*



***COREN President, Engr. Ali A. Rabiu, FNSE giving a goodwill message at the 2020 Annual Conference.***

*Principal Partner, Integrated Advanced Quest Eng. Ltd., Engr. Rufai Abdulazeez (l), MNSE, receiving an award of recognition for his firm's dedicated continuing professional development presented by ACEN Past President, Engr. Bayo Adeola, FNSE, FAEng.*

# ACEN ACTIVITES IN PICTURES

## ACEN AGM: 4TH - 5TH NOVEMBER 2020

*Principal Partner, Gapec Consultants Ltd. - Engr. George C. Okoroma (l), FNSE, JP receiving an award of recognition for his firm's dedicated continuing professional development presented by ACEN Past President, Engr. Bayo Adeola, FNSE, FAEng.*

*Principal Partner, Engr. Charles 'Yele Akindayomi (l), FNSE receiving an award of recognition for his firm's dedicated continuing professional development presented by ACEN Past President, Engr. Bayo Adeola, FNSE, FAEng.*

*ACEN President, Engr. George C. Okoroma, FNSE, JP (7th left) and the Immediate Past President, Engr. Charles 'Yele Akindayomi, FNSE (8th left) flanked by esteemed ACEN members inducted in 2020.*

*Honourable Minister of Water Resources, Engr. Suleiman Adamu, FNSE, FAEng (3rd left) flanked by ACEN President, Engr. George C. Okoroma, FNSE, JP (immediate left), ACEN Vice President, Engr. Ajibade F. Oke, FNSE (2nd left); Chairman, 2020 AGM Planning Committee, Engr. Sam Otenaike, FNSE (immediate right); Member, 2020 AGM Planning Committee, Engr. Ibrahim Maimaje, FNSE (2nd right); Engr. Tauheed Amusan, FNSE (3rd right); ACEN Managing Director, Engr. Sunday Kalejaiye, MNSE (4th right).*

ACEN
Association for Consulting Engineering in Nigeria

*ACEN President, Engr. George C. Okoroma, FNSE, JP flanked by Engr. Y.O. Sagaya, FNSE, FAEng, OFR (right) and Senator Iyiola Omisore, FNSE, CON at the event.*

# ACEN ACTIVITES IN PICTURES

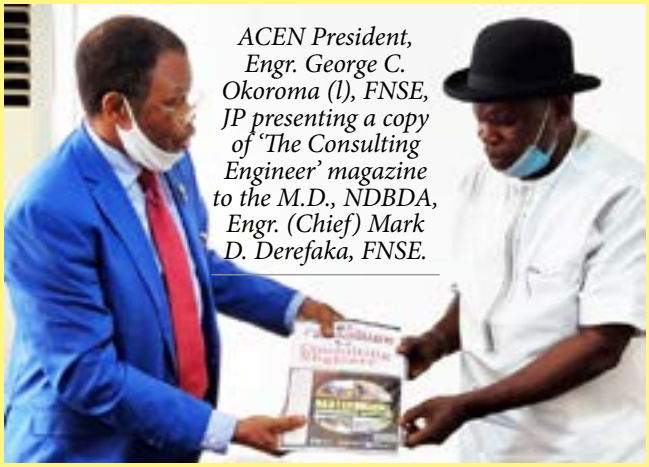
## ACEN AGM: 4TH - 5TH NOVEMBER 2020

*Mallam Muhammad Bashir Mai-Bornu who represented the Guest of Honour, Honourable Minister of the Federal Capital Territory (FCT), Mallam Muhammad Musa Bello, delivering address.*

*Cross-section of delegates at the event.*

## COURTESY VISIT TO NIGER DELTA BASIN DEVELOPMENT AUTHORITY
## 2ND FEBRUARY, 2021

*ACEN President, Engr. George C. Okoroma (l), FNSE, JP and Managing Director, NDBDA – Engr. (Chief) Mark D. Derefaka, FNSE at the courtesy visit to the Niger Delta Basin Development Authority.*



*ACEN President, Engr. George C. Okoroma (l), FNSE, JP presenting a copy of 'The Consulting Engineer' magazine to the M.D., NDBDA, Engr. (Chief) Mark D. Derefaka, FNSE.*

*Managing Director, NDBDA – Engr. (Chief) Mark D. Derefaka, FNSE flanked by other key officers of the parastatal and the ACEN delegation led by ACEN President, Engr. George C. Okoroma, FNSE, JP (immediate left); Engr. Anthony Nwogbo, FNSE (2nd left); Engr. Fyne Ogolo, FNSE (4th left); Engr. Otunte Otueneh, MNSE (5th left); Engr. Jones Nwadike, FNSE (immediate right).*

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## 2021 ACEN SCHOOL OF CONSULTING ENGINEERING (ASCE) TRAINING CALENDAR

| S/N | DATE | MONTH | COURSE | VENUE | DAYS | CPD Pt. |
|---|---|---|---|---|---|---|
| 1. | 16th – 17th | March | Preparation of Bids & How to Bid for Contracts | ONLINE | 2 days | 15 |
| 2. | 30th – 31st | March | Building Services Design - Mechanical (Module 2) | | 2 days | 15 |
| 3. | 14th – 15th | April | Structural Design of Buildings to Eurocode 2 (Module 1) | | 2 days | 15 |
| 4. | 11th – 13th | May | Electrical Engineering Design and Detailing | | 3 days | 20 |
| 5. | 16th | June | Communication and Public Speaking for Engineers | | 1 day | 10 |
| 6. | 4th – 15th | July | FIDIC Course:FIDIC Conditions of Contract for EPC/Turnkey Projects | | 2 day | 20 |
| 7. | 4th – 5th | August | Design & Construction of Flood and Erosion Control StructuresConditioning | | 2 days | 15 |
| 8. | 21st – 23rd | September | Design & Strategies in the Selection and Adoption of Mechanical Systems: Heating Ventilation & Air Conditioning | | 3 days | 20 |
| 9. | 12th – 13th | October | Electrical Power Distribution System Planning for Medium Voltage Network (Module 1) | | 2 days | 15 |
| 10. | 16th – 17th | November | Geometric Design of Roads, Intersections and Interchanges | | 2 days | 15 |

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**Workshop Fees:** (Prices are subject to review)
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**REQUESTS FOR IN-HOUSE TRAINING ARE ALSO WELCOME**
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## "THE CONSULTING ENGINEER" PERSONALITY

# PERSONALITY INTERVIEW WITH
# ENGR. (DR.) JOSEPH IBIKUNLE FOLAYAN, FAEng, FNSE

### (PAST PRESIDENT, SECRETARY AND LONG-TERM SERVING EXECUTIVE COUNCIL MEMBER, ACEN)

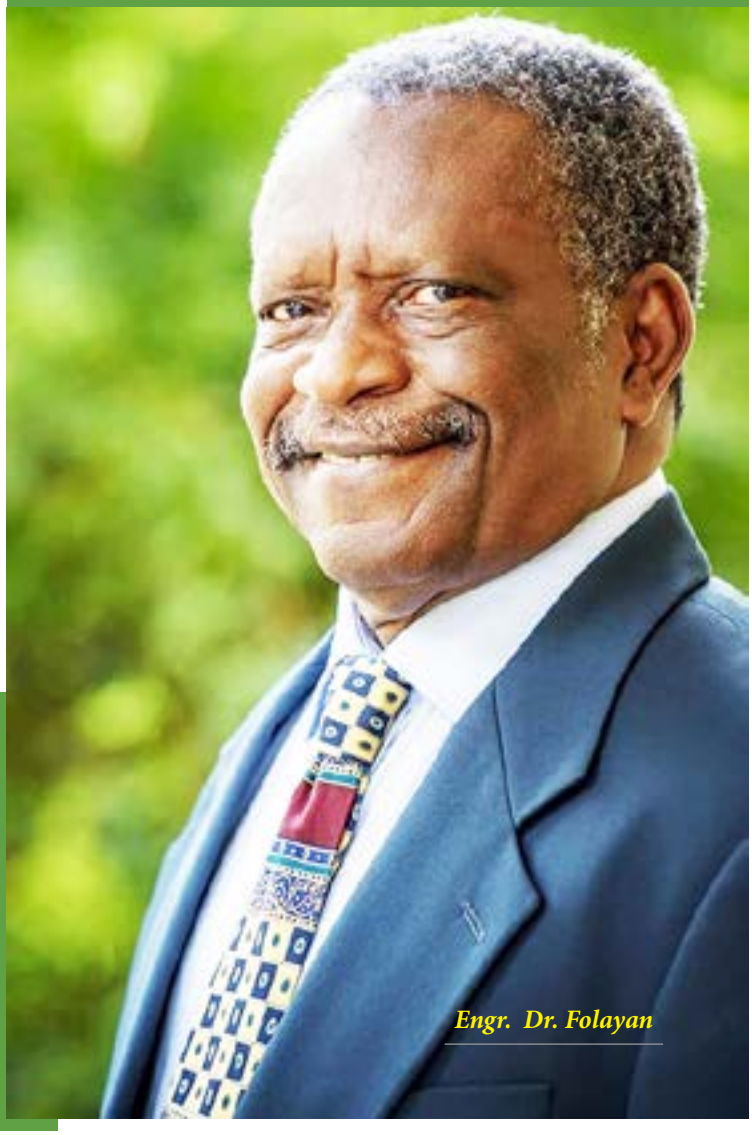
**TCE MAGAZINE:** We are very excited to meet you, Engr. Dr. Folayan on behalf of "The Consulting Engineer" magazine. Having successfully practised engineering for very many years, looking back, what motivated you to study "Engineering"?

**FOLAYAN:** After the West African Examination Council (WAEC) examinations, I enrolled for physics and pure and applied mathematics for the General Certificate of Education Advanced Level (University of London). After successfully passing the Advanced Level exams, I was admitted into Ahmadu Bello University, Zaria, to study civil engineering. I was equally admitted to the University of Southern California. So, to some measure civil engineering found me as much as I found it.

*"...I was admitted into Ahmadu Bello University, Zaria, to study civil engineering. I was equally admitted to the University of Southern California. So, to some measure civil engineering found me as much as I found it."*

**TCE MAGAZINE:** In what way has the study of engineering impacted your life?

**FOLAYAN:** I consider myself fortunate to have had the opportunity to study civil engineering and to have done so at the University of Southern California where I was on a Federal Government scholarship programme. Civil engineering is part of the bedrock of



*Engr. Dr. Folayan*

*"...fortunate to have had the opportunity to study civil engineering and to have done so at the University of Southern California."*

*"I have equally been involved in many memorable projects in Nigeria over the years including: CBN Headquarters (Abuja), Federal Secretariats (Lagos, Abuja and 16 other states capitals) and multiple projects for Shell Petroleum Development Company."*

civilization and my training in the university from undergraduate to graduate level provided me with an excellent academic foundation in the subject. I was equally fortunate to have practical training during my post graduate studies while at Stanford University from where I obtained my Masters and PhD degrees in Engineering. My practical training was obtained at Dames & Moore, a multi-national firm engaged in applied earth sciences including geotechnical engineering. The opportunity allowed me to work on several significant and groundbreaking projects. I have equally been involved in many memorable projects in Nigeria over the years including: CBN Headquarters (Abuja), Federal Secretariats (Lagos, Abuja and 16 other states capitals) and multiple projects for Shell Petroleum Development Company.

**TCE MAGAZINE:** What has your working experience been like?

**FOLAYAN:** I started as the Principal-in-Charge of Progress Engineers in July 1971. By 2018, Progress Engineers had offices in Lagos, Ibadan, Ilorin and Warri and had completed over 800 projects for both public and private sector clients in the fields of agricultural, geotechnical, transportation, building and environmental engineering covering every state in Nigeria. Geotechnical engineering has been the primary area of specialization of Progress Engineers and is my particular area of specialization. I am grateful for the opportunity to have had a long and successful career in my chosen field of endeavour.

**TCE MAGAZINE:** Based on your several years of engineering practice and activities in the Association for Consulting Engineering in Nigeria, any thoughts/ reflections on engineering practice in Nigeria?

**FOLAYAN:** Of course, I have many reflections.

Reflection on the history of ACEN, how it started, the challenge of garnering national membership and ensuring that deliveries from members were first class. The Association will forever be grateful to the founding President, Engr. F.A.O Philips, all past presidents and Council members for their sacrifices and contributions in terms of their time and resources.

However, I'd particularly like to highlight my reflections on professional ethics in consulting engineering practice. I recall that approximately 50 years ago when I entered engineering practice, various national societies of professional engineers had codes of ethics. These codes of ethics provide sets of rules on how engineers should perform. At the international level, the International Federation of Consulting Engineers (FIDIC) places an emphasis on the role of independent consulting engineers whose professional ethics should assure clients that their services are rendered in accordance with high standards and acceptable conduct while offering independent judgement in decision affecting clients.

ACEN's Code of Ethics was developed in line with those of FIDIC and UK Association of Consulting Engineers. The Code placed emphasis on honesty, impartiality, knowledge, competence, among other virtues and avoidance of conflict of interest, inappropriate behaviour and action unbecoming of a professional and reputable engineer.

**TCE MAGAZINE:** What legacy would you like to leave behind?

**FOLAYAN:** My hope is that those called to engineering continue to grow the profession with competency and integrity and hold each other to high standard of ethics.

I'm proud of my years in leadership at ACEN and hope the association will continue to thrive and be led by capable and competent leaders in the engineering profession in Nigeria.

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# ENGINEERING MANAGEMENT IN ROAD CONSTRUCTION

BY ENGR. IDOWU ISAIAH ADERIBIGBE

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

## 1.0 INTRODUCTION

Construction Management Association of America (CMAA) defines 'Construction Management' as "A professional service that applies effective management techniques to the planning, design and construction of a project from inception to completion involving the control of time, cost and quality." Road construction precedes road maintenance. Thus, engineering management of road construction places emphasis on effective construction supervision to ensure technically appropriate construction procedures are followed to achieve durability, quality and safety. Roads constructed to high technical quality normally require minimal maintenance in the short-term when the types of vehicles meant for such roads ply on them.

## 2.0 ROAD CONSTRUCTION

A road is a thoroughfare, route or way on land between two places that has been paved or otherwise improved to allow travel with the use of a horse, cart, bicycle or motor vehicle. Roads consist of one or more lanes and any associated sidewalks and road verges. Roads that are available for use by the public may be referred to as public roads or as highways. The Organization for Economic Co-operation and Development (OECD) defines a road as "A line of communication using a stabilized base, other than rails or air strips, open to public traffic primarily for the use of road motor vehicles running on their own wheels which include bridges, tunnels, supporting structures, junctions, crossings, interchanges and toll roads but not cycle paths."

Road construction requires the creation of a continuous right-of-way, overcoming geographic obstacles and having grades low enough to permitvehicle or foot travel whichmeet standards set by law or official guidelines. The process often commences with the removal of earth and rock by digging orblasting, construction ofembankments, bridges, tunnels and removal of vegetation (this may involve deforestation) and followed by the laying of pavement material.Various types of road building equipment are employed in road construction.

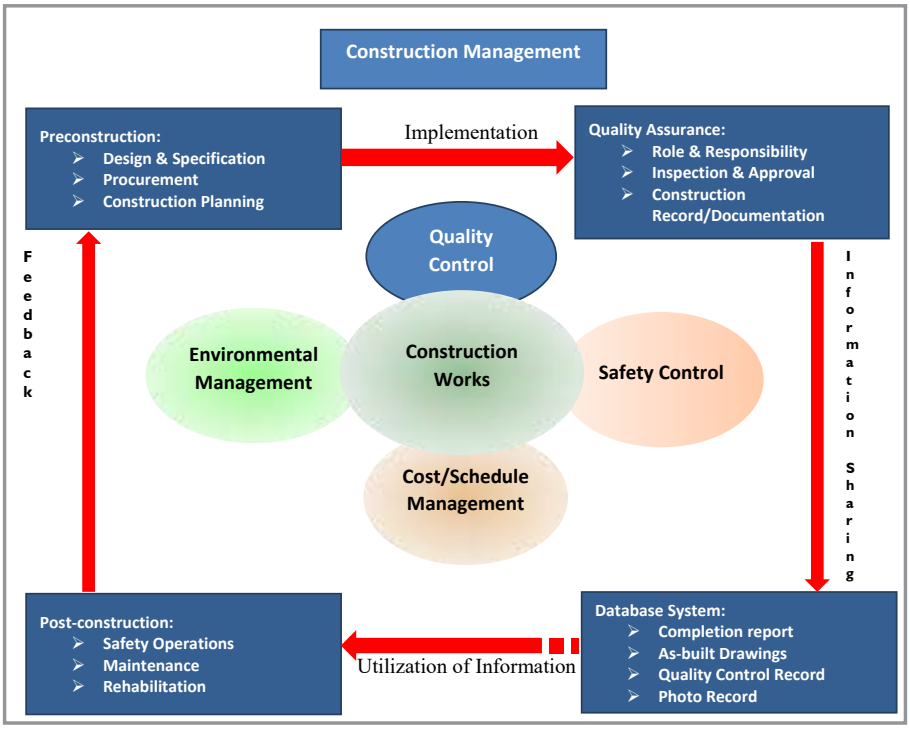


**Fig. 1:** *Components of construction management*

## 3.0 ROAD MANAGEMENT PHASES

The main phases of road management are:

- Concept
- Planningand Preliminary Design
- Construction
- Operationand Maintenance

The focus of this write-up is the 'ConstructionManagement' phase ofengineering management in road construction.

### 3.1 MANAGEMENT AT THE CONSTRUCTION PHASE

Fig. 1 shows the components of construction management. There is a need to develop efficient construction management system so as to achieve quality and safety in road construction work. At this phase of construction, emphasis is

placed on schedule, cost, change controls configuration management, document control, quality assurance and safety management. In the construction phase, the contracting firm procured by the client, in collaboration with the firm's consultants and engineers, is involved in the road project construction. The work is done in accordance with the plans and specifications developed during the design phase. After the construction, the facilities and equipment are integrated and tested in the commissioning phase. The project's highest levels of activity, in terms of numbers of personnel and costs incurred per day, occur during construction. The construction phase, however, has ample opportunities for cost overruns due to changes and delays, disputes with contractors and the resulting contract changes and claims.

### 3.2 ROLES AND EXPECTATIONS IN THE CONSTRUCTION PHASE

The major entities in the road construction phase are the client, the designer and the contractor. Their roles can be described as follows:

#### 3.2.1 The Client

The best way the client can ensure the project succeeds with good performance is by making timely and decisive decisions. A delay or indecision during construction is significantly costlier and can result in substantial claims for compensation for extended overhead by the contractor. Changes in scope can result in expensive re-work such as demolishing and replacing some parts of the construction work. Delaying one contractor may delay other contractors resulting in further claims. Further to this, there should be:

- Clear lines of communication and delegated authority
- The project manager assigned by the client should be given free hand to operate within the ambit of his/her responsibilities.

#### 3.2.2 The Design Consultant

In most cases, the design consultant also serves as the construction supervising consultant. To ensure the project succeeds, the design/ supervising consultant should:

- Focus on quality control of construction works
- Receive and respond speedily to the contractor's requests for information (RFI) communicated by the contractor to the designer through the construction manager
- Review and recommend acceptance of contractor submittals called for in the drawings and specifications with respect to the construction deliverables
- Review change requests and estimate costs for change orders
- Make periodic visits to the site to ensure compliance with the design specifications and provide certification as required by the authorized agency

#### 3.2.3 The Contractor in Construction

The role of the construction contractor is to:

- Perform construction work defined by the contract drawings and specifications using the means and methods available to its firm
- Obtain the permits related to the work
- Develop and implement a quality control (QC) plan for inspection and testing of the work
- Develop and implement a safety plan to ensure a safe work site
- Deliver submittals defined by the contract drawings and specifications
- Submit RFIs to the construction manager to obtain clarifications of the design intent
- Submit request for change.

## 4.0 CONTRACT MANAGEMENT AND ADMINISTRATION

### 4.1 MEETINGS

The client's representative (the project supervising consultant) and the contract administrator meet with the contractor on a regular basis to assess the contractor's progress. At these meetings, the contractor reports on the progress. Issues that arise in the field are addressed and any disputes resolved.

### 4.2 PUBLIC RELATIONS MANAGEMENT

Public information (PI) is the practice of managing the flow of information between the client and the public including stakeholders. Common activities of PI include presentation at conferences, working with the press and communication with employees on their activities and achievements. For excellent service delivery, acceptability of the project and total public satisfaction, response to queries, complaints, concerns and other needs of external stakeholders including road users, civil society groups, non-governmental organizations, development partners, the academia, other government agencies, etc. need to be taken seriously. (See Table 1).

| Audience | Communications Guidelines |
|---|---|
| Local Community and Business Groups | Identify project impacts of concern to local community and business groups. |
| | Communicate frequently and timely on the status of the project and associated impacts (community meetings, informational newssheets). |
| | Demonstrate sincere empathy and understanding on adverse impacts. |
| | Mitigate adverse impacts (limit construction at nights/ weekends, provide temporary signage where access to business is impacted during construction). |
| Media | Limit media contact to designated Agency personnel. |
| | Ensure contractors refer all media comments to the Agency. |
| | Establish the Agency's position and message on project issues |
| | Address media questions so as to communicate the Agency's message. |
| | Cultivate the media to present positive news on project events. |
| Political Stakeholders | Above all else make certain a political stakeholder is not taken by surprise by a project event, good or bad. |
| | Regularly brief political stakeholders on project events and issues. |
| | Discuss project issues with political stakeholders before they comment or decide on them in public such as at a board meetings or media interviews. |
| | Include political stakeholders in project milestone events so that their support and contributions can be recognized. |

**Table 1:** *Managing Communications*

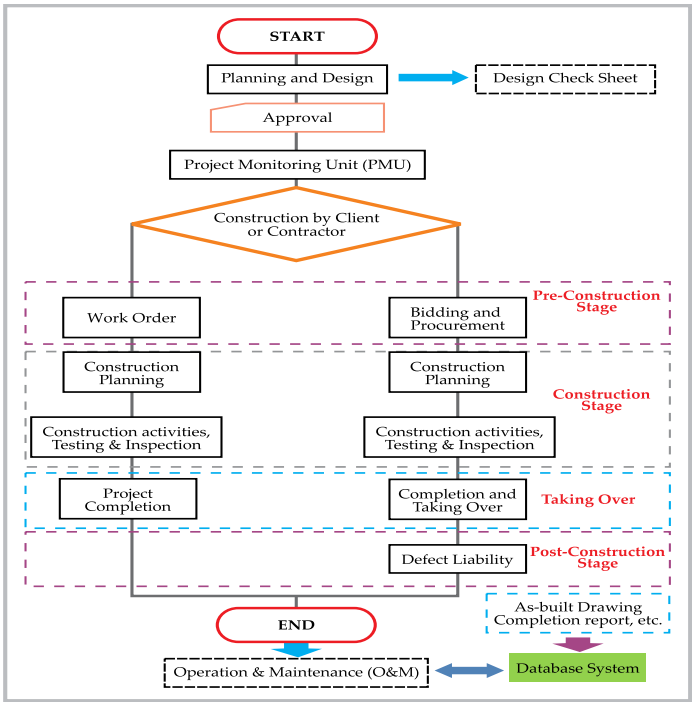


**Fig. 2:** *Flowchart of Construction Management*

### 4.3 SAFETY MANAGEMENT

The safety of lives and properties of the workmen and users of the road is key at every phase of the project implementation. To ensure this, the contractor shall:

- Comply with all applicable safety regulations
- Take care of the safety of all persons entitled to be on the site
- Use reasonable efforts to keep the work site clear of unnecessary obstruction so as to avoid danger to workers
- Provide fencing, lighting and security guards for the project until completion and handing over where necessary
- Provide any temporary alternative road access which may be necessary in the course of the execution of the project for the use and protection of the public including owners and occupants of the land and the properties adjacent to the project site

### 4.4 ENVIRONMENTAL MANAGEMENT

Democratic decision-making is indispensable for environmental and social considerations through public and stakeholder participation, information transparency and accountability.

The Environmental Impact Assessment (EIA) process should:

- Entail all relevant information on the affected environment, proposed alternatives and their impacts and of the measures necessary to monitor and investigate residual effects.
- Have clear EIA content and ensure public access to information. Also identify the factors that are to be considered in decision making
- Address the interrelationships of social, economic and biophysical aspects.

## 5.0 CONCLUSION

The thrust of engineering management in road construction is construction management top deliver the propject in line with design specifications safely and cost effectively.

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# ENGINEERING MANAGEMENT IN FACTORY OPERATIONS

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## 1.0 INTRODUCTION

In the past, a major aspect of engineering was designing assembly lines and planning the layouts of factories and other manufacturing models. In recent times, engineers work to eliminate wastes of time, money, materials, energy and other resources to achieve in lean manufacturing operations. Engineering management is used when firms require a combination of management know how and special technical knowledge to transform organizational performance, enhance knowledge and keep any intellectual property developed confidential.

Engineering management entails developing, implementing, improving and evaluating integrated systems of organizations, information, people, energy, money, materials, knowledge, equipment, and/or processes. It is aimed at improving existing organization's processes, products or systems. It relies on the principles and methods of engineering analysis and synthesis, as well as the mathematical, physical and social sciences coupled with the principles and methods of engineering design. This steps lead to the specification, prediction and evaluation of the results to be obtained from such systems or processes. Engineering management also focuses on the social impact of the product(s), process(es) or system(s) that are being analysed. There is also an overlap between engineering management and management science in services that require the adoption of more analytical approaches to problem solving.

In a developing economy like Nigeria, engineering management is a critical tool in developing and leading a company-wide business transformation initiative or designing and implementing a new product development process, designing and implementing a manufacturing engineering process including an automated assembly workstation. One ramification in the scope of engineering management in factory operations is the use of the expertise of external engineering consultants to add value to the firm. The external consultant may be local or a foreign technical partner who is knowledgeable enough to augment the services of in-house engineering managers in factory operations. In summary, engineering management is simply the application of the practice of management to the practice of engineering because applied science and engineering practice require a holistic approach involving a combination of management art, science and engineering practice.

From engineering management perspective, industries can be classified on the basis of production processes, plant layout, production planning in a factory etc. A factory or manufacturing plant can be regarded as an industrial site which consists of machinery and buildings or more often a complex consisting of several buildings where workers manufacture various goods or operate machines for processing one product to obtain another product.

## 2.0 CLASSIFICATION OF INDUSTRIES BASED ON PRODUCTION PROCESS

The type of industry and the method of the manufacturing process play a significant influence in the plant layout/factory operations.
Industries, in this context, may be broadly classified into four types:

(a) Synthetic production process
(b) Analytical production process
(c) Conditioning production process
(d) Extractive production process

***"Engineering management entails developing, implementing, improving and evaluating integrated..."***

Extractive industries involve the separation of one element from another, as in the case of metal from the ore. Air conditioning industry involves a change in the physical properties. Metal working industries, foundries, leather tanning and petroleum refining involve re-conditioning of the raw materials to create the end products. An oil refinery, for example, yields naphtha, gasoline, paraffin, tar and kerosene. Similarly, a sugar mill gives, besides sugar, bagasse and molasses. A synthetic industry, also called the assembling industry, involves the production of a product by the use of various elements. In other words, various elements go into the manufacture of an end-product. The chemical industry and the paper industry are synthetic process industries. Each of the above types of industries may be further classified into two types, namely:

(a) Intermittent/Discontinuous industrial production and
(b) Continuous industrial production.

This classification is based on the method of manufacture or production. Intermittent industries manufacture different components on different machines and assemble them to get the end products. Continuousindustries produce one or two products to a specification without interrupting the process. Continuousproduction involves the use of facilities that are standardized as to routing and flow of the raw materials or inputs. The materials are passed through a series of successive connected operations in anticipation of customer demand rather than in response to customer orders. Examples of industries using such technology are mattresses, petroleum, chemicals, steel and sugar industries.

We can again classify the continuous industries into: (1) Mass production system and (2) Process production system.

(a) Mass Production - This system of production is used where manufacturing is carried out continuously in anticipation of demand, though demand of the product may not be uniform throughout the year. Standardization is vital in any mass production process. Standardized raw materials and machines are used to produce standardized products through standardized process of production.

(b) Process Production - This system is an extended form of mass production where production is carried out continuously through a uniform predetermined sequence of operations. Generally, under this system, the finished product of one process is used in the next process as the raw material till the last process is carried out. Process production calls for the setting up of automatic machines and equipment as far as possible. Large industries like petroleum refining and heavy chemical industries generally use this system of production.

*"It is done more often on the basis of customer orders."*

Intermittent production systems are those where the facilities must be flexible enough to handle a wide variety of products and sizes or where the basic nature of activity imposes change of important characteristics on the input. Under this system, no single sequence of operations is appropriate. Therefore, standardized materials or machines cannot be used. Under this type of manufacturing, production is done in lots rather than on a continuous flow basis. It is done more often on the basis of customer orders.

The chief characteristics of intermittent industries are that components are made for inventory but they are combined differently for different customers. The finished product is heterogeneous but assembled by the producers within a range of standardized options. Since production is partly for stock and partly for customer demand, there are problems in scheduling, forecasting, control and coordination. Examples of such industries are automobile industry, electrical goods manufacturing plants, printing presses etc.

Intermittent system of production may further be divided into two types, namely (a) job and (b) batch production.

(a) Job Production - In this system, goods are produced according to the orders of the customers. Continuous demand of such items is not assured. Therefore, production is done only when the orders for the manufacture are received from the customers.

(b) Batch Production - Under this system, the manufacturing is done in batches or groups or lots either on the basis of customer's order or with the hope of a continuous demand of the product. Under this system, medium scale production is the norm.

In batch production, machines and equipment are made available for the next batch as soon as the production of the first batch is completed.

## 3.0 PLANT LAYOUT

Plant layout, also known as layout of facility, generally refers to the configuration of departments, work-centres, equipment and machinery with focus on the flow of materials or work through the production system. Plant layout or facility layout involves planning for location of all machines, equipment, utilities, work stations, customer service areas, material storage areas, tool servicing areas, tool cribs, aisles, rest rooms, lunch rooms, coffee/ tea bays, offices and computer rooms as well as planning for the patterns of flow of materials and people around, into and within the buildings. Layout planning involves decisions about the physical arrangement of economic activity centres within a facility. An economic activity centre can be anything that occupies space, a person or group of people, a machine, a work station, a department, an aisle, a store room and so on. The goal of layout planning is to allow workers and equipment to operate more effectively.

### 3.1 FACTORS INFLUENCING LAYOUT CHOICES

Primarily, the layout of a plant is influenced by the relationship among materials, machinery and workers. Other factors influencing layout are type of product, type of workers, type of industry, management policies etc.

Some of these factors are discussed in details below:

#### 3.1.1 Location

The size and type of the site selected for the plant determine the type of buildings (single story or multi-storey) which in turn influences the layout design. Also, the location of the plant determines the mode of transportation from and into the plant (such as the use of goods truck). In the layout design, provision should be made for facilities in consonance wirh the mode of transport to be used. The layout should provide for storage of fuel, raw materials, future expansion needs, power generation requirements etc.

#### 3.1.2 Machinery and Equipment

The type of product, the volume of production, type of processes and management policy on technology determine the type of machines and equipment to be installed which in turn influence the plant layout.

#### 3.1.3 Managerial Policies

Policies on the volume of production, provision for future expansion, extent of automation, make-or-buy decisions, speed of delivery of goods to customers, purchasing and inventory policies and personnel policies influence the plant layout design.

#### 3.1.4 Materials

Plant layout entails provision for storage and handling of raw materials, supplies and components used in production. The type of storage areas, racks, handling equipment such as cranes, trolleys, conveyors or pipelines, etc all depend on the type of materials used. Such materials may be solid, liquid, light, heavy, bulky, big, small, etc.

#### 3.1.5 Product

The type of product influences the type of layout because the product may be light or heavy, big or small, liquid or solid, etc. For example, ship building, aircraft assembly and locomotive assembly require a layout type different from that needed to produce refrigerators, cars, scooters, television sets, soaps, detergents, soft drinks, etc.

#### 3.1.6 Type of Manufacturing Industry

Industrial manufacturing can be carried out by intermittent operations or continuous operations. Industry classification, in terms of synthetic production process, analytical production, conditioning productionor extractive production, may fall into the sub-classifications called intermittent and continuous manufacturing (See Fig. 1)

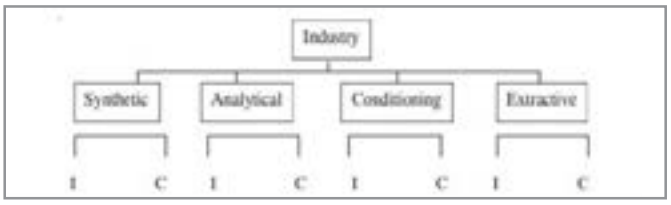


**Fig 1:** *Type of manufacturing industry (I is intermittent type of manufacturing industry, C is continuous type of manufacturing industry)*

#### 3.1.7 Workers

The gender of employees (men or women), the position of employees while working (i.e., standing or sitting), employee facilities needed such as locker rooms, rest rooms, toilets, canteens, coffee/tea bays, etc are to be considered while designing the plant layouts.

### 3.2 PLANT LAYOUT PRINCIPLES

Plant layout principles serve as guides in layout design. These principles are:

### 3.2.1 Principle of Minimum Travel
Men and materials should travel the shortest distance between operations so as to avoid waste of labour and time and minimise the cost of materials handling.

### 3.2.2 Principle of Sequence
Machinery and operations should be arranged in a sequential order.

### 3.2.3 Principle of Usage
Every unit of available space should be effectively utilised. This principle should receive top consideration in towns and cities where, land is costly.

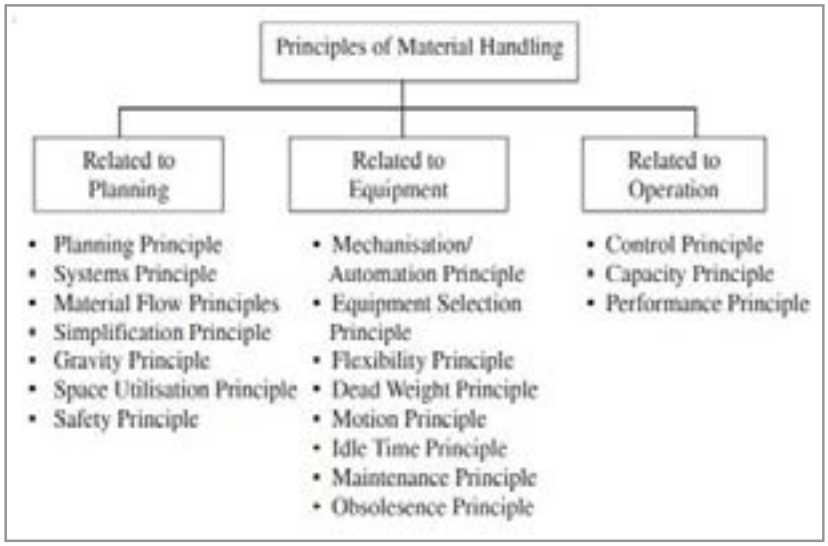


**Fig 2:** *Principles of material handling*

### 3.2.4 Principle of Compactness
There should be a logical integration of all the relevant factors so that the final layout is systematic and compact.

### 3.2.5 Principle of Safety and Satisfaction
The layout should contain built-in provisions for safety of the workmen. It should also be planned on the basis for the comfort and convenience of the workmen.

### 3.2.6 Principle of Flexibility
The layout should permit revisions with the least difficulty and at minimum cost.

### 3.2.7 Principle of Minimum Investment
The layout should result in savings in fixed capital investment not by avoiding installation of the necessary facilities but by an intensive use of available facilities.

## 3.3 MATERIALS HANDLING SYSTEM

### 3.3.1 Definition and Objective
In factory operations, materials handling is an integral part of the manufacturing process. In order to manufacture any product, it is essential to move the material from one place to another. To start with, material must be moved, prior to production, from the storage room to processing. There may also be inter-departmental transfer of materials or finished goods from the final conversion point to final inspection point. Finally, the products are conveyed to the finished goods warehouse and then shipped to customers. In a general sense, materials handling includes all movements of materials in a manufacturing enterprise. Materials handling is defined as the art and science involving the conveyance, packing and storing of substances in any form.

The objectives of materials handling are mainly:

- To improve production performance and reduce costs
- To improve the work environment for shop floor personnel

### 3.3.2 Principles of Material Handling
Materals handling is a service function. It is not an end in itself. The principles of materials handling can be grouped under three broad headings shown in Fig. 2.

# 4.0 PRODUCTION PLANNING AND PRODUCTIVITY MANAGEMENT
Effective production planning and productivity management involve time study, work study, method study and job evaluation in factory operations.

## 4.1 TIME STUDY
Time study aims at determining the best way of doing a job and recording the time of performance of the job when done in the best way. It is defined as the scientific analysis of the methods and equipment used or to be used for doing a piece of work, involving the practical details of the best way of doing it and determination of the time required. Operation analysis on the other hand, is the study of the entire process to determine whether the operations can be combined or the sequence changed. Operation analysis aims at determining the best way to apply to the method, material(s), tool(s), equipment layout, working conditions and human requirements of each operation. Further to this, job standardisation consists of determining the best way of performing

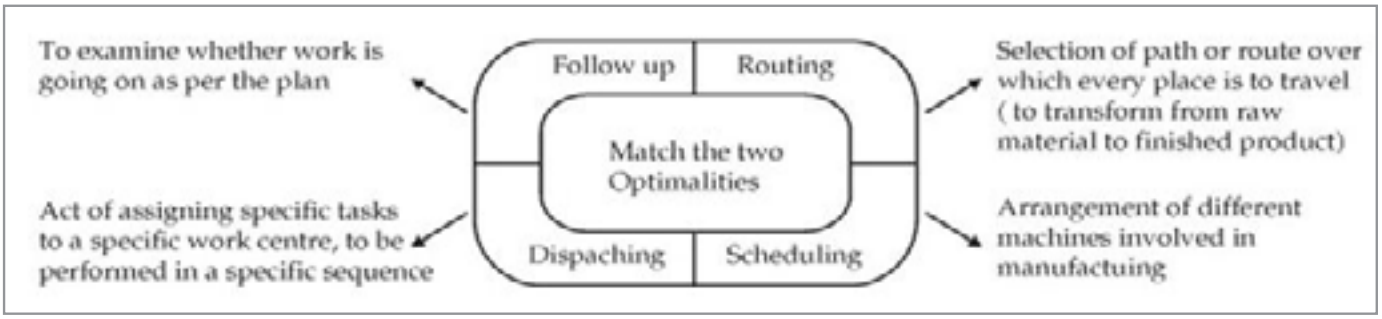


**Fig. 3:** *Production planning and control*

a job. This takes cognizance of recording the exact method and time for each element of operation and maintaining such standard conditions.

### 4.2 WORK STUDY

Work study is a general term for the techniques, methods study and work measurement which are used in the examination of human work in all its ramifications including the systematic investigation of all factors leading to improvement of efficiency. Work study aims at finding the best and most efficient way of using the available resources—men, materials, money and machinery. Once the method study has developed an improved procedure for doing a piece of work, the work measurement or time study will be used to measure the time to complete the job.

### 4.3 METHOD STUDY

Method study is the systematic investigation of the existing method of doing a job in order to develop and install an easy, rapid, efficient, effective procedure for doing the same job and at minimum cost. This is achieved by eliminating unnecessary motions involved in a certain operation or by changing the sequence of operation or the process itself. A new and improved method developed in one department is usually spread out to the entire plant preferably with further improvements.

### 4.4 JOB EVALUATION

Job evaluation is the ranking, grading, and weighing of essential work characteristics of all jobs in order to find out or rate the worth of jobs. It is a systematic approach towards ascertaining the labour worth of each job. Employers usually pay great attention to job evaluation.

### 4.5 PRODUCTION PLANNING AND CONTROL

Production planning and control can be viewed as the nervous system of a production/factory operation. The primary objective of production planning and control is the delivery of products to customers or to inventory stocks according to some predetermined schedule. All the activities in the manufacturing or production cycle must be planned, coordinated, organised and controlled to achieve this objective. From a long-term point of view (usually from seven to ten years or more), production planning is a major factor in plant construction and location, number of product lines design and development (See Fig. 3).

### 4.6 FORECASTING

Forecasting means peeping into the future. Though the future is unknown and is anybody's guess, business leaders in the past have evolved certain systematic and scientific methods to assess the future by scientific analysis based on facts and possibilities. This systematic method of probing into the future is called forecasting. Forecasting of sales refers to an act of making prediction about future sales followed by a detailed analysis of facts related to future situations and forces which may affect the business as a whole.

### 4.7 CAPACITY PLANNING AND UTILIZATION

The effective management of capacity is the most important responsibility of production and operations management. The objective of capacity management i.e., planning and control of capacity, is to match the level of operations to the level of demand. Capacity planning is concerned with finding answers to the basic questions regarding capacity such as:

(i) What kind of capacity is needed?

(ii) How much capacity is to be utilized?

(iii) When is this capacity needed?

Capacity planning is to be carried out keeping in mind future growth and expansion plans, market trends, sales forecasting, etc. Capacity is the rate of productive capability of a facility. Capacity is usually expressed as volume of output per period of time e.g 200,000mt/yr of product.

***"Process improvement is the systematic study of the activities and flows of each process so as to improve the process".***

### 4.8 PROCESS PLANNING

In a factory setting, process is a sequence of activities that is intended to achieve some result, typically to create added value for the customers.

Types of Processes:

(i) Conversion Processes: These involve converting the raw materials into finished products (for example, converting polyurethane to sandwich panel). The conversion can be a metallurgical or chemical or construction processes.

(ii) Manufacturing Processes: These are divided into forming processes, machining processes and assembly processes.

(iii) Testing Processes: These involve inspection and testing of products (sometimes considered as part of the manufacturing processes).

Process planning is defined as the systematic determination of methods by which a product is to be manufactured economically and competitively. It consists of selecting the proper machines, determining the sequence of operations, specifying the inspection stages, tools, jigs and fixtures such that the product can be manufactured to the required specification. The detailed process planning is done at each component level.

After the final design of the product has been approved and released for production, the Production Planning and Control Department takes the responsibility of process planning and process design toward converting the product design into a tangible product. As the process plans are firmly established, the processing time required to carry out the production operations on the equipment and machines selected are estimated. These processing times are compared with the available machine and labour capacities and also against the cost of acquiring new machines and equipment required, before a final decision is made to manufacture the product completely in house or a consideration of any parts or sub-assemblies which may require outsourcing. The process planning activity is usually carried out with minute details as to how each component can be manufactured. It consists of process design and operations design.

Process design is concerned with the overall sequences of operations required to achieve the product specifications. It specifies the type of work stations to be used, the machines and equipment necessary to carry out the operations. The sequence of operations is determined by the nature of the product, the materials used, the quantity or quantities to be produced and the existing physical layout of the plant.

Operations design is concerned with the design of the individual manufacturing operation. It examines the man-machine relationship in the manufacturing process. Operations design must specify how much labour and machine time is required to produce each unit of the product.

### 4.9 PROCESS IMPROVEMENT

Process improvement is the systematic study of the activities and flows of each process so as to improve the process. Once the process is thoroughly understood, it can be improved upon. Process improvement becomes necessary because of relentless pressure to provide better quality at a lower price. The basic techniques for analysing the processes include the use of flow diagrams and process charts. Improvements can be made in quality, through-put time, cost, errors, safety and timely delivery.

## 5.0 CONCLUSION

In conclusion, effective engineering management of factory operations entails planning, organising, directing and controlling factory operations in such a way that quality products, which meet customers' expectations in a timely manner, are produced safely in well maintained factory facilities.

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# ENGINEERING MANAGEMENT OF ELECTRICAL PROJECTS

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## 1.0 INTRODUCTION

Engineering management of electrical projects can be viewed from two perspectives, namely engineering management and electrical project. Engineering management of electrical projects uses the same standard methodologies and processes as any other type of project management. The focus of this paper is electrical project management.

## 2.0 DEFINITION OF AN ELECTRICAL PROJECT

Electrical project is an engineering project concerned with the study, design and application of equipment, devices and systems which use electricity, electronics and electromagnetism. Examples include hydro power generation, building electrification etc. Electrical engineers work in a wide range of industries and the skill set required is wide.

An electrical engineering project involves the application of effort to achieve planned objectives and produce a specific output or outcome. Every project is unique with a defined scope, starting date and ending date. The outputs are tangible and expressed as deliverables such as document reports, drawings, constructions, etc. A project has a specific schedule and budget that define indicators of performance. In addition and since electricity is a service, coordination with other disciplines such as civil, mechanical and process engineering is important.

## 3.0 PROJECT MANAGEMENT

Project management is recognized as a discipline that involves the application of knowledge, techniques, experiences, tools and skills to project activities in order to successfully accomplish all the project objectives and meet client requirements. There is a lot of information about approaches and methodologies to run projects. A body called Project Management Institute (PMI) has developed a guide that establishes the common processes and best practices applied to most projects. These techniques and processes should be adapted to each project in relation to its uniqueness. It should be noted that objectives are achieved by executing processes in consonance with other recognized management standards such as ISO 9000. Each process interacts with others. It also has inputs, tools / techniques to be applied. The end result is, of course, the outputs.

### 3.1 PROCESS GROUPS IN PROJECT MANAGEMENT

There are five established process groups in project management as follows:

#### 3.1.1 Initiating

This involves all the processes applied for starting a new project. It entails obtaining authorization from the organization's management and sponsor.

#### 3.1.2 Planning

Planning processes establish the scope of work, the objectives to be accomplished, schedules to follow, designs to be used, budget to serve as a guide and quality issues, among others.

#### 3.1.3 Executing

Executing processes are the actual activities carried out within the project scope and project plan which end with implementation.

#### 3.1.4 Monitoring and Controlling

These activities entail reviews, checks and tracking actions to determine any deviation from the project plan in the course of project execution.

#### 3.1.5 Closing

Closing processes entail the activities carried out to formally end the project. Typical of such an activity is project commissioning. These steps apply to any type of electrical engineering project.

## 4.0 SUCCESSFUL PROJECT MANAGEMENT IN ELECTRICAL ENGINEERING

The recipe for success in an electrical engineering projects is a balance of the applications of skills, experience and knowledge. This balance will normally lead to positive results. Some of the issues which are important towards achieving success are:

### 4.1 SCOPE DEFINITION

Project scope must be detailed and specifically defined in the early stage. It should be written in a document and reviewed by all project team members. Out of scope activities should be mentioned in order to easily detect any deviation. Any activity done outside of the approved scope will affect schedule and budget. Specification of materials should be clearly stated and not ambiguous.

### 4.2 MAKING REAL PLANS

Plans should be made considering the defined scope and requirements, taking into account all the tasks, responsibilities and milestones. Plans must be real based on available resources (human, technological, financial etc), employee work schedules and quality issues. If the scheduled plan does not meet project requirements such as ending date, actions must be taken by the organization to find out if more resources are needed. Such actions may involve hiring more staff, buying new equipment, among others and committing them to the project.

### 4.3 RISK ANALYSIS

Risks are always present and can affect project objectives positively or negatively. Identifying possible risks at the beginning of the project is really important. The real causes of risks should be identified and how to prevent them on the basis of pre-event and post-event plan. Risk analysis is important in electrical project management so as to avoid surprises particularly hazards affecting human safety.

### 4.4 WORK ENVIRONMENT

Projects are carried out by people. A better environment will bring better results, adaptation to changes and commitments to the achievement of objectives. Work environment can be improved by good and open communication, training, rewards and flexibility. It is, therefore, important to understand the feelings of employees in relation to project objectives.

### 4.5 TRACKING AND MONITORING

These activities entail the evaluation of the work already done in relation to the project plan. Any deviation from the plan must be studied and corrective actions should be taken. Tracking and monitoring are applied to assess project performance using key indicators such as efficiency, efficacy, earned value, etc. These indicators are usually shown on a dashboard. The indicators serve as guides to ensure project completion on time and within the budget.

## 5.0 ENGINEERS AND RELEVANCE OF PROJECT MANAGEMENT SKILLS

### 5.1 COMBINING TECHNICAL AND NON-TECHNICAL SKILLS

Engineering skill is essential in working effectively on an engineering project. On the other hand, managing the engineering project requires the application of managerial skill or managerial acumen. Thus, a successful engineering project execution relies on both technical and non-technical skills because of the synergy derived from the technical knowledge of the engineer and the non-technical skill of the project manager. In electrical engineering project, for instance, the skilled knowledgeable electrical engineer in the team will seek to deliver quality electricity by the time the project is completed. When engineering skill is combined with project managerial skill, the project is not likely to suffer defects of engineering quality, budget overrun and lack of safety.

### 5.2 CAREER ADVANCEMENT

Career advancement is another reason engineers should acquire project management skills. It provides opportunity to climb the ladder of the engineering firm to the position of a partner or even president. Maintaining one's engineering relevance requires consistent study, reading of engineering journals, magazines and attending training courses. William S. Boroughs had something to say about consistent growth: "When you stop growing you start dying."

***"Risks are always present and can affect project objectives positively or negatively".***

***"Project management entails not only technical issues but also non-technical issues."***

Engineers who stop advancing their skills would not literally die but would stand a good chance of failing in their career. Studying project management will provide the engineer with the knowledge of the processes, procedures, planning ability, control expertise and effective delivery of projects.

### 5.3 VALUE ADDITION

Knowledge of project management skills increases the benefit of the engineer to his/her organization and to the client. This is very crucial to the ongoing efforts by government to develop Nigeria's infrastructure. Both clients and the engineer's organization want projects to be properly scoped and kept within that scope; controlled to a realistic schedule and constrained to the planned budget. Developing the skill set needed to make this happen will take experience but it will also require study.

### 5.4 IMPROVED EFFICIENCY

When project management skill is acquired, it leads to increased efficiency on the part of the engineer being able to move from the initial phase of the project to successful project delivery. Specifically, this means that the engineer has a mental model for the various phases of a project. Clear knowledge of standard operating procedures, use of flowcharts and templates and general understanding of the project will lead to improved efficiency in delivering the project.

### 5.5 ENHANCED EFFECTIVENESS

The project manager is responsible for the control of a project so it remains within scope, schedule and within the budget. The project manager leads and communicates with project team members and the stakeholders. A project manager's effectiveness is pegged to the individual's ability to understand that 80% of what they will be doing day by day is non-technical work – communicating with someone, managing the expectations of stakeholders, handling personnel issues in the project management team, etc. The project manager's effectiveness in handling any of the issues that will arise will be determined by his skills and experience.

### 5.6 POSITIONING TO REPLICATE SUCCESS

One way the engineer can position himself to replicate success in electrical project management is to use standard operating procedures (SOP), checklists and templates. The SOPs help to increase efficiency and enhance effectiveness by eliminating the time needed to re-create them.

Another reason is that when an SOP contributes to a successful project delivery, then it is easy to replicate that success by using the same SOP on the next project. Experience helps in developing SOPs that become enduring, as well as understanding which ones must be modified for other projects. However, standardizing up to 60% of activities from one project to the next can provide adequate time for monitoring and controlling the project's key performance indicators, managing risk and fulfilling the client's expectations.

### 5.7 LEARNING LEADERSHIP AND COMMUNICATION

Project management entails not only technical issues but also non-technical issues. Developing project management skills provides the engineer with the foundation for developing the other skills required such as leadership, communication and strategic assessment.

### 5.8 COMMON OPERATING LANGUAGE AND 'PICTURE'

The study of project management will provide the engineer with a common operating language and 'picture' on how project management is supposed to be conducted. Once the foundation is laid, the engineer can make well-informed adjustments to fit into any industry, organization or unique situations. The engineer would also be able to look back at past projects and identify where the application of the body of knowledge of project management may have yielded a different or better result.

## 6.0 CASE STUDY USING THE CONSTRUCTION OF KATAMPE SUBSTATION, ABUJA

### 6.1 DEFINITION OF A SUBSTATION

An electrical substation can be defined as a network of electrical components comprising power

transformers, busbars, auxiliaries and switchgear among others. The components are interconnected in a way that creates a circuit capable of being switched OFF while running on normal operation through manual commands while in emergency situations it can be switched OFF automatically.

The emergency situations may be earthquakes, floods or short circuit, etc. An electrical substation does not have a single circuit but is composed of numerous outgoing and incoming circuits which are connected to a busbar common to the circuits. The substation receives electrical energy directly from generating or transmission stations through incoming power supply lines while it delivers electricity to the consumers through outgoing transmission lines.

### 6.2 PROJECT SCOPE OF KATAMPE SUBSTATION, ABUJA

The project scope of KatampeSsubstation, Abuja covered design, procurement, construction and commissioning of 2x150MVA, 330/132kV and 2x60MVA, 132/33kV switch gear with double busbars, connection to a new 330kV transmission line and existing 132kV transmission line and construction of residential houses for operations and maintenance staff. The elements of a substation include primary power lines, secondary power lines, ground wire, overhead lines, voltage measuring transformer, disconnection switch, circuit breaker, current transformer, lightning arrester, main power transformer, control building and security fence.

**Fig. 1:** *The Katampe Substation, Abuja*

### 6.3 APPLYING THE FIVE PROCESS TECHNIQUES OF PROJECT MANAGEMENT

#### 6.3.1 Initiating

The need to supply electrical power to the unserved Katampe community and its environs give birth to the construction of the electrical substation in the area The project was initiated by NEPA (TCN) which had to obtain an authorization from the Federal Ministry of Power before embarking on the project.

#### 6.3.2 Planning

This involved establishing the scope of work, objectives to accomplish, schedule to follow, design, budget and quality issues, among others. Consultants were appointed to handle these aspects of the project.

#### 6.3.3 Executing

An electrical contracting firm was selected to execute the project within the defined scope and in line with the activities indicated in the project plan.

#### 6.3.4 Monitoring and Controlling

These aspects were carried out by all the team members involved in the initiation, planning and execution phases. The works included all the activities necessary for review, checking and tracking the project performance in order to determine any deviation from the plan.

#### 6.3.5 Closing

The components of this activity were commissioning and handing over the project to the client The Katampe Substation project was completed in 2013. See Fig. 1.

## 7.0 CONCLUSION

The success story of many electrical engineering projects in the context of Nigeria's infrastructural development can be traceable to the correct application of management skills in the project execution. Therefore invariably, greater success is achievable in electrical engineering project delivery when combined with the skill of project management.

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# BRIDGE DESIGN & CONSTRUCTION MANAGEMENT

BY ENGR. AILEME UNUIGBE

*Engr. A. Unuigbe*
*(Principal Engineer, AICOL Consulting Engineers)*

## ABSTRACT

*This paper provides salient considerations to the design requirements for a bridge structure and the important quality control and quality assurance issues to be observed in bridge construction. A bridge can be described as a structure built to span and provide passage over a river, chasm, road or any other physical hurdle. The function required from the bridge and the area where it is constructed are important factors in the design of the bridge.*

*All major bridges are built with public funds. Therefore, bridge design that best serves the public interest has a threefold goal: to be efficient, economical and safe. Inherent in the threefold goal is elegance. Efficiency is a scientific principle that puts a value on reducing materials while increasing performance. Economy is a social principle that puts value on reducing the costs of construction and maintenance while retaining efficiency. Finally, elegance is a symbolic or visual principle that puts value on the personal expression of the designer without compromising performance or economy. There is little disagreement over what constitutes efficiency and economy, but the definition of elegance has always been controversial.*

## 1.0 INTRODUCTION

Usually in transportation and highway management, bridges are required to convey traffic whether pedestrian or vehicular between one location and another. A bridge usually crosses an obstructing body such as river, grade traffic, railway or other social infrastructure.

## 2.0 TYPES OF BRIDGES

Bridges are generally classified by function and design. On the other hand, bridges are also categorized as pedestrian crossing or very light traffic overpass and vehicular traffic bridge designed as simply supported or continuous span type. Figs. 1-6 show basic types of bridges described in form and support system

### 2.1 BEAM BRIDGE

A beam bridge is known for being the simplest and most cost-effective bridge to build (See Fig. 1). Beam bridges include the simply supported bridges and the continuous or multi-span bridges. The beam bridges can also be categorized by materials as follows:

- Reinforced concrete beam bridges
- Prestressed concrete beam bridges (I-section and Box girders)
- Composite girder bridges - steel, polymer and concrete

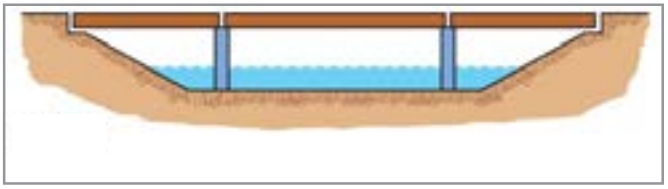

**Fig. 1:** *A beam bridge*

### 2.2 CANTILEVER BRIDGES

As the name implies, a cantilever bridge has supports at piers and has the cantilever ends at the mid-span. The cantilevers carry their loads by tension in the upper chords and compression in the lower ones. Inner towers carry those forces by compression to the foundation and outer towers carry the forces by tension to the far foundations. The only forces generated at the bearings are horizontal and vertical forces. (See Fig. 2).

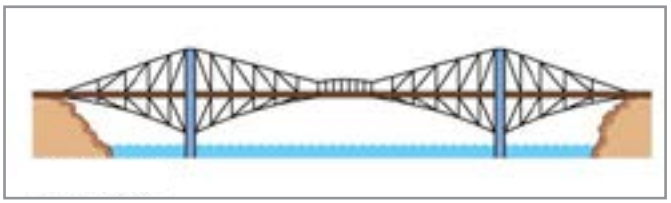

**Fig. 2:** *A cantilever bridge*

### 2.3 ARCH BRIDGES

These are mainly constructed of masonry materials and designed as 2-pinned or 3-pinned arch designs. These bridges were previously utilized in early to mid-20th century. The arch bridge carries loads primarily by compression which exerts both vertical and horizontal forces on the foundation. Arch foundations must therefore prevent both vertical settling and horizontal sliding. In spite of the more complicated foundation design, the structure itself normally requires less material than a beam bridge of the same span. (See Fig. 3).

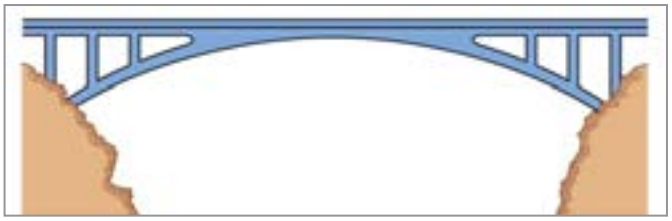

**Fig. 3:** *An arch bridge*

### 2.4 CABLE-STAYED BRIDGES

Cables are designed to support the bridge deck structure between pylons. The pylons or towers transfer the cable forces to the foundations through vertical compression. The tensile forces in the cables also put the deck into horizontal compression. These types of bridges are usually deployed over river estuaries or wide canal hydraulic passages. Several variants of cable-stayed bridges have been developed over the last several decades such as the extradosed bridge. Materials for construction have been primarily steel beams and precast slab deck structure. (See Fig. 4).

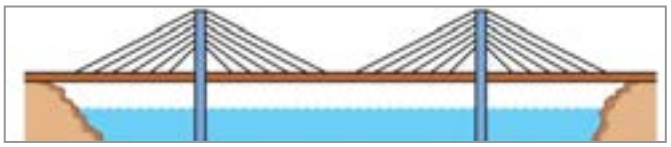

**Fig. 4:** *A cable-stayed bridge*

### 2.5 TRUSS BRIDGES

Truss bridges are mostly designed and constructed using steel trusses supporting a concrete bridge slab deck or a steel orthotropic plate bridge deck. Trusses are popular because they use a relatively small amount of material to carry relatively large loads. Trusses consist of many small beams that can support a large amount of weight together and span great distances. In most cases, the design, fabrication and erection of trusses are relatively simple. (See Fig. 5).

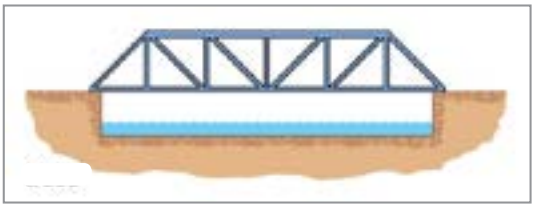

**Fig. 5:** *A truss bridge*

### 2.6 SUSPENSION BRIDGES

Suspension bridges vary from cable-stayed bridges in respect of the methods of design. These types of bridges carry vertical loads through curved cables in tension. These loads are transferred both to the towers, which carry them by vertical compression to the ground and to the anchorages which must resist the inward and sometimes vertical pull of the cables. The suspension bridge can be viewed as an upside-down arch in tension with only the towers in compression. Considering that the deck is hung in the air, care must be taken to ensure that it does not move excessively under loading. The deck, therefore, must be either heavy or stiff or both. (See Fig. 6).

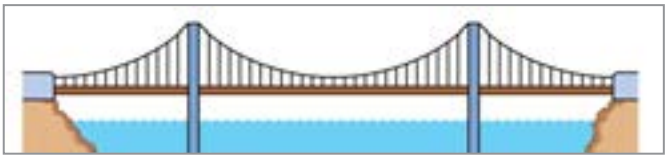

**Fig. 6:** *A suspension bridge*

## 3.0 BRIDGE DESIGN AND CONSTRUCTION MANAGEMENT

After a route for a bridge has been decided and the form of bridge has been agreed upon, the next phase is to execute a structural design of the infrastructure. A typical design management will be used to describe the process and flow of this exercise.

A bridge structure is divided into two main parts namely the substructure and the superstructure. The substructure comprises the structural members transferring the loads to the foundation. This may include the pile cap and piles and sometimes pad footings, single or combined with Socrates protective layers especially in river crossings. The superstructure is the summary of all foundation structural members which are above and include the columns or piers, girders, bridge deck slab as well as deck barriers for retention. The approach or transition to bridge slab is also designed to take care of eventual soil settlement that may occur at the bridge approach areas. Other very useful appurtenances of the superstructure are the following:

**Fig. 7:** *A pot bearing*

**Fig. 8:** *An elastomeric bearing*

**Fig. 9:** *A neoprene bearing*

**A. Bearings:** These are interface support of girders and are supported on abutment or piers. The different bearing types are shown in Figs. 7 – 9.

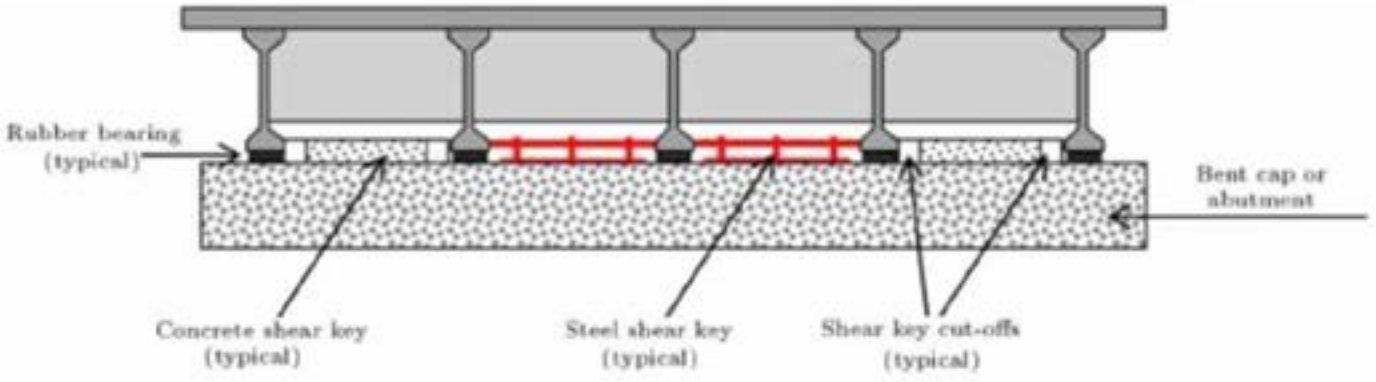


**Fig. 10:** *A cross section of a typical bridge showing bearings, shear keys and other structural elements*

The positioning of bearings is shown in Fig. 10.

**B. Shear Keys:** These are provided to restrain the bearings from 'walking' – excessive horizontal movement.

**C. Bridge Deck Joints:** These allow for movement in the bridge structure in three orthogonal directions. Figs. 11-12 show construction details for various types of bridge deck joints while Fig. 13 shows a completed joint.

**Fig.11:** *A strip seal block out construction*

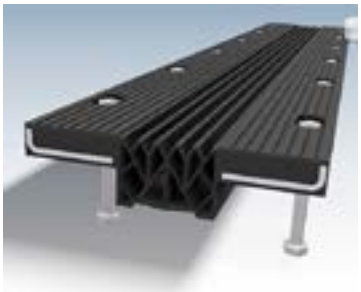

**Fig. 12:** *A strip seal for wider movement*

**Fig. 13:** *A completed joint*

**D. Associated Retaining Walls at Abutments:** The retaining walls serve as boundaries to the structure. See Fig. 14

*Fig. 14: Retaining walls (wing walls) in front abutment supports*

## 4.0 DESIGN MANAGEMENT

The design of bridges requires an understanding of the behavior of bridge structures in service based on knowledge and experience. Many practising bridge engineers have also utilized prevailing bridge design standards and specifications from local authorities having jurisdiction for such development. Bridge design standards across many regions of the world include BS5400 (UK), AASHTO, CSA S6 (Canada) and other design guidelines and manuals for different bridge types.

Bridges by performance are also categorized as integral or not integral bridges. Integral bridges are characterized by the monolithic construction of the superstructure and substructure of the bridge components. As with many other structural engineering infrastructures, bridge designs follow the following steps:

I. A plan of the site should be prepared showing all obstacles to the bridge such as rivers, streets, roads or railroads, the contour lines of valleys and the desired alignment of the new traffic route.
II. There should be a design drawing of the longitudinal section of the ground along the axis of the planned bridge with the conditions for clearance or required flood widths as well as the desired vertical alignment of the new route.
III. There should be a drawing showing the required width of the bridge, width of lanes, median, walkways, safety rails, etc.
IV. There should be a geotechnical report on soil conditions for foundations, results of borings with a report on the geological situation and soil mechanics data. This is because the degree of difficulty of foundation work has a considerable influence on the choice of the structural system and on the economical span length.
V. Local conditions like accessibility for the transport of equipment, materials and structural elements should be ascertained. Consideration should be given to the materials available in the community for

economic reasons provided the materials are suitable for use. Answers should be sought to the following questions: Is water or electric power at hand? Can a high standard of technology be used or must the bridge be built with primitive methods and a small number of skilled laborers?

VI. Weather and environmental conditions, floods, high and low tide levels, periods of drought, range of temperatures and length of frost periods should be ascertained.

VII. An additional factor to consider in the design is topography of the environment in terms of open land, flat or mountainous land or scenic country. There is need to also consider whether the town is one with small old houses or a city with high rise buildings.

VIII. Consideration in design is also influenced by environmental requirements regarding aesthetic quality. Bridges in towns that affect the urban environment and that are frequently seen at close range, especially pedestrian bridges, need more delicate shaping and treatment than bridges in open country. As part of the design consideration, the following questions need answers: Is protection of pedestrians against spray and noise needed? Is noise protection necessary for houses close to the bridge?

## 5.0 STRUCTURAL DESIGNS AND COMPUTATIONS

Structural designs of bridges require the use of softwares. Details on computations are also available in standard bridge design texts. A summary is provided below:

A. Member type selection and sizing consideration

B Loads and loading combinations

C. Structural analysis and result checks for ultimate limit state and serviceability limit state and other criteria for the concrete deck and reinforced girders under different loads

D. Elemental design of the following structural members such as:

*i. Pier cap and abutment (stage 1 and 2 combinations)*

*ii. Pier or column design*

*iii. Deck barrier*

*iv. Wing walls and Retaining walls*

*v. Bridge approach slab*

*vi. Bearings*

*vii. Foundation - Pile and Pile cap design*

*viii Deck Joints*

## 6.0 CONSTRUCTION MANAGEMENT

Construction of a bridge, as is also applicable to any public infrastructure, requires a process and if followed correctly will produce a very functional bridge system. The procedure consists of:

- Breaking ground and installation of foundation piles/pile cap and abutment wingwalls
- Compaction of soil on abutment slope.
- Fixing of pour abutment seats and pier cap.
- Installation of bearings
- Placement of girder
- Decking
- Installation of deck joints
- Railings installation or construction of concrete barriers
- Painting and Decoration
- Testing

## 7.0 CONCLUSION

As previously stated above, the design of bridges requires experience and the understanding of behavior of bridge structures in service. The designer should have first seen and studied many bridges in the course of a long learning process in order to design a new bridge. He should know what type of beam may be suitable under the prevailing condition(s), either a beam bridge, an arch bridge or a suspended one. He should also know the influence of foundation conditions on the choice of spans and structural systems, etc. Thus, the designer of the bridge should not only be a learned person but also an experienced one. Many practising bridge engineers have also utilized prevailing bridge design standards and specifications from local authorities having jurisdiction for such development. The wide knowledge and experience are key factors in effective management of bridge construction.

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- Kotangora
- Bama, etc

*** The Gwandu Formation of the North West tip of Nigeria:**
- Gwandu
- Birni Kebbi
- Kangiwa

*** The Clay and Shale formation of Sokoto**
- Sokoto

*** Southern Coastland from Lagos to Calabar of:**
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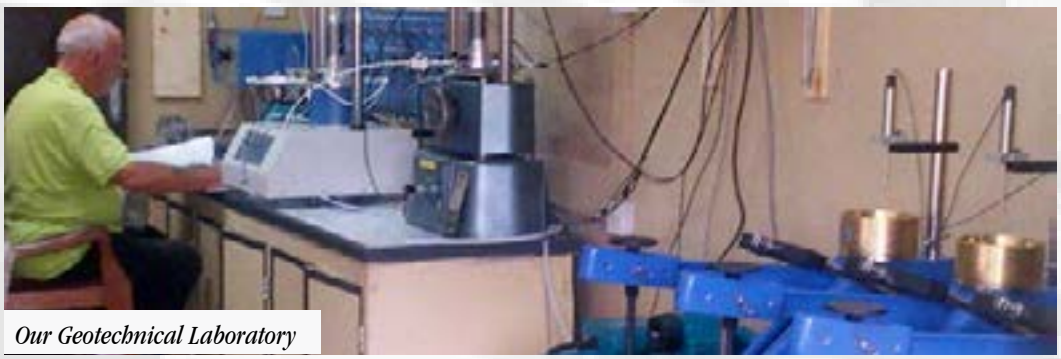

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# ENGINEERING MANAGEMENT OF THERMAL POWER PLANTS

BY ENGR. AGHA OGBONNAYA

***Engr. Agha Ogbonnaya***
*(Head, Plant Services, Planning And Technical Training, Afam Power Plc)*

## 1.0 INTRODUCTION:

A thermal power plant is a power plant in which heat energy is converted to electricity via a gas turbine or a steam turbine connected to a generator.

| NAME | HEAT SOURCE |
|---|---|
| Egbin | Gas |
| Geregu I | Gas |
| Geregu II | Gas |
| Omotosho I | Gas |
| Omotosho II | Combined Gas & Steam |
| Olorunsogo I | Gas |
| Olorunsogo II | Combined Gas & Steam |
| Alaoji (Aba) | Combined Gas & Steam |
| Ibom (Akwa Ibom) | Gas |
| Calabar (Odukpami) | Gas |
| Afam I, II, III, IV & V (under transfer to Transcorp Plc) | Gas |
| Afam VI (Shell) | Combined Gas & Steam |
| Ughelli | Gas |
| Sapele Ogorode | Steam |
| Sapele NIPP | Gas |
| Okpai (AGIP) | Combined Gas & Steam |
| Rivers IPP (Afam) | Gas |
| Trans Amadi IPP | Gas |
| Omoku IPP | Gas |
| NIPP Gbaiain (not completed) | Gas |
| Egbema (not completed) | Gas |
| Ajaokuta (Non-functional) | Steam |
| AES Nigeria Barge (Egbin) Non-functional | Gas |
| Parex Energy (Non-functional) | Gas |

**Table 1:** *Thermal Power plants in Nigeria*

Fig. 1 shows a simple schematic diagram of a gas turbine while Fig. 2 shows a simple diagram of a steam turbine. The thermal power plants in Nigeria are listed in Table 1.

The engineering management of a thermal power plant focuses on measures that enhance the plant's availability and reliability meant to translate into sufficiency of electrical power supply to the customers based on the plant capacity. The availability and reliability of the plant depend on the maintenance policy as well as maintenance practices.

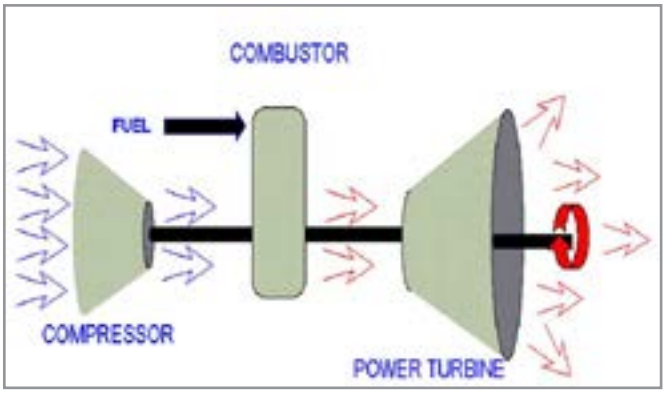


**Fig. 1:** *A simple diagram of a gas turbine*

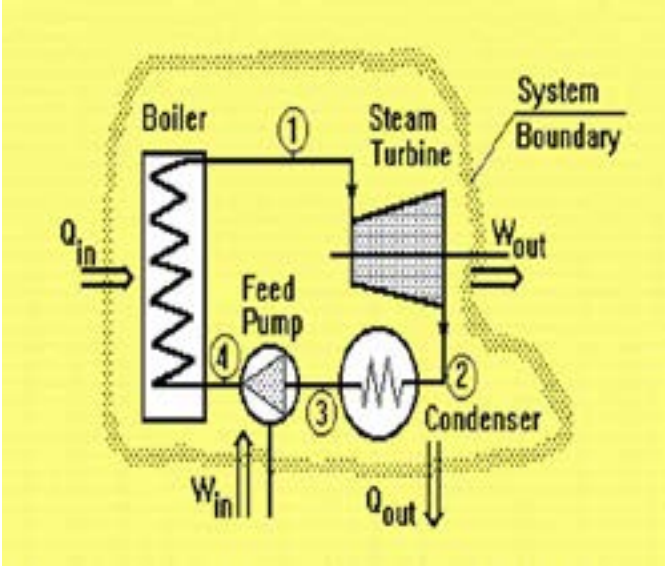


**Fig. 2:** *A simple diagram of a steam turbine*

*A thermal power generation plant in Nigeria*

## 2.0 ENGINEERING MANAGEMENT IN RELATION TO INDUSTRY BEST PRACTICES

Effective engineering management of a thermal power plant seeks to achieve industry best practices in all their ramifications. Availability of the plant and optimal efficiency of the plant are essential goals. In this context, all the units and machines must operate effectively in order for the entire plant to deliver power output optimally. The vital areas which contribute significantly to effective plant performance are discussed below:

### 2.1 ENERGY EFFICIENCY

A great deal of attention should be paid to energy efficiency in addition to plant load factor. A good management practice entails carrying out regular energy audits (including efficiency tests for boiler, turbine and other sub-systems). The use of a computer-based system for online monitoring of energy efficiency performance is the industry best practice. Such a system allows the heat rate to be monitored on a unit-wise basis (rather than for the whole plant) in real time through online measurement of gas consumption and electricity generation. The calorific value of the gas fed to the plant itself must be known.

### 2.2 GAS ACCOUNTABILITY

Accurate measurement of the quantity as well as the quality (calorific value) of the gas is important because it has direct bearing on the technical and commercial performance of the plant.

### 2.3 WATER CHEMISTRY

Water quality and make-up quantity especially for steam plants need to be monitored systematically to reduce any tendency of boiler tube failure and deposits on turbine blades.

### 2.4 DOCUMENTATION OF OPERATING PROCEDURES

Operational procedures should be well documented for use by the technical staff. This will reduce the use of subjectivity in attending to operational issues. Proper use of operational procedures increases equipment availability, reliability and life.

### 2.5 OPERATIONAL DATA

Operational data should not just be for the archives. They should be systematically utilized to generate information on the operational and maintenance requirements based on the trend analysis.

### 2.6 THE ROLE OF ORIGINAL EQUIPMENT MANUFACTURER

Operation and maintenance (O&M) manuals should be supplied by the original equipment manufacturer (OEM) for use by management and staff of the plant. The O & M manuals should be placed in a centralized library for controlled access by the relevant staff as the need arises.

### 2.7 TRAINING

There is need for adequate training of staff so that procedures, contents in operating manuals and

> *" Such training should include the use of 'Power Plant Simulator.' "*

instructions are well understood. Such training should include the use of 'Power Plant Simulator'. Refresher courses are essential for experienced staff to reinforce the awareness of these procedures and eliminate complacency.

### 2.8 AUXILIARY CONSUMPTION MONITORING SYSTEM

As part of good management practice, an auxiliary consumption monitoring system has to be deployed to monitor the energy consumption and operating parameters of auxiliaries such as the boiler feed pump. Typically, the current drawn by the pump should be monitored.

### 2.9 STEAM AND WATER PARAMETERS

The conductivity, pH values, phosphate content of water should be measured online in real time through the steam and water analysis system. Similarly, a good practice is to measure condensate conductivity online to ascertain whether there are condensate tube leakages. Historical trends of such parameters can reveal malfunctions and areas of potential improvements in plant efficiency.

### 2.10 DEPARTMENTALIZATION

As part of effective engineering management of thermal power plants, specific departments should be assigned responsibilities to carry out vital tests such as boiler efficiency, air pre-heater X-ratio, turbine cylinder efficiency, cooling towers efficiency and efficiency tests for heaters and deaerators.

*A thermal power plant in Southeast Nigeria*

### 2.11 DAILY OPERATIONAL REVIEW

Operational meeting holding daily under the chairmanship of the Head of Operations and Maintenance Department is a common practice for a well run plant. The review is essential to be able to forge ahead and achieve power generation target.

### 2.12 KNOWLEDGE MANAGEMENT

Knowledge is power and serves as the key to successful operations of a thermal power plant. Operational data should, therefore, be properly stored for future reference. Supporting departments such as stores, procurement, finance, environment, human resources, e.t.c need to provide data from their departments to enhance the overall management of the plant.

## 3.0 CONCLUSION

Although there has been significant progress in improving the operational and maintenance practices of several power plants in Nigeria, some thermal generation plants are yet to institutionalize the above-mentioned industry-best practices for sustained good performance. However, improving operations and maintenance practices is a challenge that requires strong management and employee commitment to be able to progress to optimal plant performance.

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# TIT-BITS ON ENGINEERING MANAGEMENT

## BY ENGR. ENEFIOK UBOM

1.0 ANTS AS ENGINEERING MANAGEMENT PRACTITIONERS

Some ants are engineering management practitioners. This is part of their innate skills. The species with this skill set include Formica, Lasius, Myrmica, among others. These skills are exhibited in the construction of ant-hills (moulds).

***Engr. Enefiok Ubom**, FNSChE*

The construction of the ant-hill by ants is naturally aimed at achieving the objectives of protection, safety, security and comfort similar to what man seeks to achieve in engineering management of any infrastructure development.

In essence, the ant-hill is not just a random structure made of pine-needles, piles of fine soil, sand or clay and tiny sticks mixed with dirt.

The solid construction is very sophisticated and is what makes the climate control of the colony possible. The ant-hill consists of two parts: the one above the ground and the other under it. Both parts have a great network of tunnels connecting many chambers of varying sizes (See Fig. 1)

As the seasons change, the different areas of the ant-hill are used to create the optimal climate for the brood and queen. When it is warm, they are taken to the top in the ant-hill. When there is a drought or it is too cold outside, they are taken down to the warm and moist areas in the lower chambers. As part of the ant-hill architecture, the surface is a crust of pine-needles filled all over with small entrances. The ants open and close them in the same way man uses doors. The difference is that while man uses doors with hinges, the ants use stones and other woodland materials to shut out weather and enemies. Interestingly also, resins from trees and plants found in ant-hills have antibacterial properties and kill off fungi in the ants' home.

For the ant-hill construction so described, the acts of planning, organizing and coordinating, directing and controlling (which are the essential aspects of engineering management) are uniquely different from those of humans. Without any prepared architectural or structural drawings commonly used in the case of human system, the individual worker ants use an incredible innate intelligence to exhibit self-planning, self-organization and coordination, self-directing and self-control in the course of collective construction of their house called the 'ant-hill'.

It is astonishing and incredibly inspiring to think that these teeny insects with equally teeny brains are able to create such marvelous

**Fig. 1:** *An ant-hill*

structures. With the level of sophistication achieved structurally in the ant-hill construction, we can describe the feat as engineering management par excellence in the insect world.

## 2.0 ENGINEERING MANAGEMENT IN DEMOLITION

Engineering management feats cannot only be achieved in construction but can also be achieved in demolition. The chequered history of the 22-storey Bank of Industry (BOI) Building at 67/71 Broad Street, Lagos comes to mind. The magnificent building was constructed in 1972. Since that time, there have been five fire incidents which culminated in its partial collapse on March 22, 2006. In reaction to this partial collapse, it was inevitable to bring down the building for safety reasons. The intriguing engineering management of the demolition is quite instructive.

The demolition of the BOI Building was unique as no bulldozer or crane was used. Rather, some 5,900 explosives were planted all over the structure and then simultaneously detonated using remote devices. The result was the crumbling of the building within 10 seconds. It was the first to be done in the history of West Africa. The demolition was executed by Wreckers Dismantling Limited of South Africa, a sub-contractor of Hitech Engineering Company Nigeria Limited.

Planning ingenuity was used at its best in the demolition exercise. Experts undertook a pre-weakening and insulation of the structure – a process which included pre-demolition drilling, installation of wire mesh and sealing of the entire structure from inside to prevent any dislodged elements from shooting out without control upon explosion impact (See Fig. 2). The Lagos State Government undertook painstaking planning for the controlled demolition operation driven by the need to ensure maximum safety, security and protection of lives and property.

**Fig. 2:** *The Bank of Industry building under demolition*

The planning culminated in the announcement of the zero hour detonation on the public address system by the then Lagos State Commissioner for Physical Planning and Urban Development, Tpl. Francisco Bolaji Abosede. Seconds after the announcement, the set of bombs exploded simultaneously generating a cacophony inside the BOI Building and everyone watching beheld with awe as the building came down together. The structure crumbled eastwards as was predicted by the experts without any of the neighboring buildings being affected by the impact of the implosion.

All key aspects of engineering management (planning, organizing and co-coordinating, directing and controlling) were brought to bear in this historic demolition operation on September 21, 2008. This successfully controlled demolition of the BOI Building was an outcome of engineering management par excellence in Lagos State.

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