The ENGINEER

A JOURNAL OF THE ENGINEERS REGISTRATION BOARD, UGANDA

Issue 4, 2019

The Engineer in the 4th Industrial Revolution

50th ANNIVERSARY 1969-2019

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Engineers Registration Board

The Engineers Registration Board (ERB) is established under the Engineers Registration Act (ERA) Cap 271, as a statutory body with a mission to regulate and control engineers and their profession within Uganda.
The function of the Board is to regulate and control engineers and their activities within Uganda, and to advise Government in relation thereto. It has wide ranging powers to register, de-register, restore registration, suspend registration, hold inquiries, hear appeals and appear as respondents

THE ENGINEER, Journal of the Engineers Registration Board

The Engineer is the Journal of the Engineers Registration Board (ERB). The journal publishes refereed research and practitioner papers on all aspects of engineering.
The readership and authorship is mainly from engineering professionals and those with interest in the engineering practice in Uganda and globally. The journal is widely read by practitioners and professionals working in academia, the civil service, consultancies, regulators, NGOs, financial institutions, and the development partners.

WORD FROM THE PUBLISHER

Feeding two birds with one seed is never easy: We publish engineering information for development, which is our pride at 8M Construction Digest Ltd. And we published for the Engineers Registration Board at their most critical period: showcasing ERB@50. It took an untiring and determined management of 8M staff, among others, led by super journal designer Miracle Arikiza, experienced in-house editor Samuel Hadido and the PRO Sheena Kabalihira! We recognise the valuable input of Moses Muwaya, Angel Nagawa, Lindah Ainebyoona, Moreen Tumwebaze, and Martin A. Walugembe. I thank my staff for walking the walk. I thank the Engineers Registration Board for the trust they put in us.
At 8M Construction Digest,
PUBLISHING IS OUR JOY!

Eng Hans JWB Mwesigwa,
Publishing Agent

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Samuel Hadido
In-House Editor

Sheena Kabalihira
Public Relations

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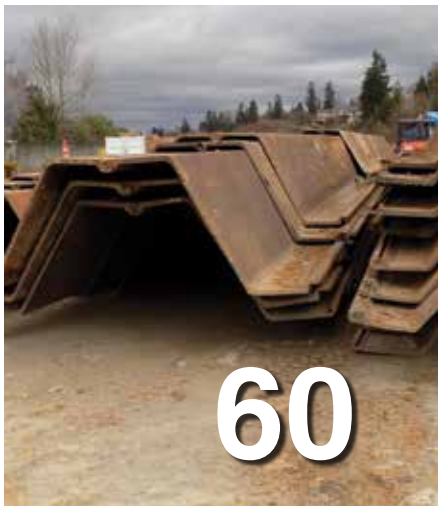

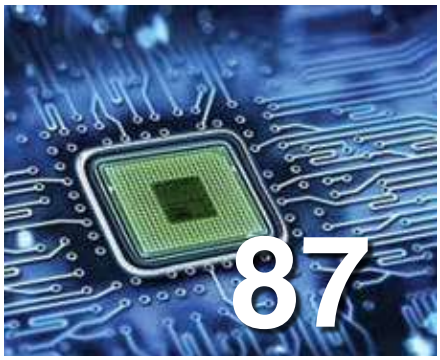

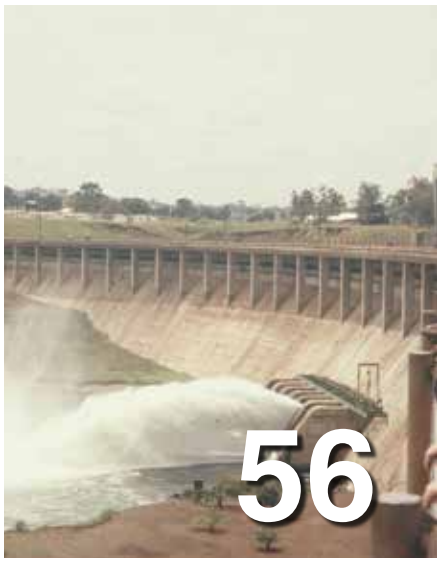

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A message from the **Editor**

Dear Reader!

Once again, it is with great pleasure that I present this edition of The Engineer, nicknamed ERB@50. The theme of this edition is also the theme of the Engineers Forum for this year, to mark the 50th year since ERB was enacted. The theme is "The Engineers' Role in the Fourth Industrial Revolution" which is a pertinent topic worth researching into in order to strategize for our future as a country. Indeed, His Excellency the President recently named our own, Eng. Hon John M Nasasira, Fellow of UIPE and former Minister of Works and Transport to head the task force on "Uganda in the Fourth Industrial Revolution".

In this issue, therefore, you will find a range of reading materials related to this theme, all tailored to inform and educate you on engineering for development. It is our hope that by publishing this rare engineering information, we are giving back to the engineering fraternity and the general public, to which we dedicate copies free of charge.

This edition of The Engineer comes out fatter and hopefully to you, dear reader, more beautiful. While we maintain that the opinions and views in the various articles are not necessarily those of ERB (and the Editorial Committee), we wish to affirm that the articles have been selected in conformity with the widely accepted understanding of engineering as the application of scientific knowledge to providing solutions to problems that affect society and for the advancement of humanity.

I will seize this moment to congratulate the engineering fraternity upon marking the 50th anniversary and also to thank all those who have made it possible to produce this year's edition of The Engineer.

In a special way I thank my Editorial Committee, the management of 8M Construction Digest, led by Eng Hans JWB Mwesigwa, members of the Engineers Registration Board, led by Eng Dr Michael M Odongo, the employers of the Editorial Committee members and the ERB members for permitting these members to take time off their busy schedules; and the ERB Secretariat led by the Registrar, Eng Ronald Namugera.

Rounds and rounds of applause should also go to our authors for the high quality papers, and to the co-sponsors of the Journal: advertisers and sponsors of the various information.

Most importantly, I thank the Almighty God, without whom nothing can be accomplished. To Him we give the glory.

Wishing you pleasant reading, a merry Christmas and a prosperous year 2020.

Eng George William Bwanga
Chairman, ERB Publication

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A foreward from the **Minister of Works and Transport**

It is my pleasure to write a foreword for this special edition of The Engineer, the journal of the Engineers Registration Board at their celebration of the board's 50th anniversary. The golden jubilee edition is to be unveiled at this year's annual Engineers Forum from 5th to 6th December 2019 at Hotel Africana, Kampala.

The theme of this year's Engineers Forum, an intriguingly great theme, is, "The Engineer in the 4th Industrial Revolution". At the forum will be gathered engineers from Uganda, Eastern Africa and the diaspora, together with other key stakeholders, to discuss the role of engineers in this cyber-age for the betterment of Uganda and Africa.

I am delighted that ERB (Engineers Registration Board) found it important to publish this special edition and capture information, not only about the theme of the forum, but also about the untold story of the ERB. The theme is particularly apt because His Excellency the President recently put in place a task force to plan the role of Uganda in the Fourth Industrial Revolution. Captured also are equally great topics under the theme, such as Eng Kant Kanyarusoke's history of the industrial revolution. This over-one-hundred-page edition of The Engineer is spiced with felicitous messages, adverts and advertorials, in support of the engineering fraternity and its important role in development.

ERB was created by Government as a regulatory body for the engineering profession. My ministry nurtured and supported the board from 1st December 1969, when the Engineers Registration Act (ERA) started. The Act gives the legal framework through which the board operates, thus supporting the work of engineers and giving them recognition countrywide and internationally. The ministry is also in the process of amending the Act to make it more relevant to the current needs in regulating the engineering profession.

My ministry gives financial support to the board for the day to day running of their activities. The board has recently acquired land at Namanve Industrial Park that will be used to build their offices and training facilities as a step towards becoming a financially self-sustaining organization.

I applaud the achievements of those who have served on the Engineers Registration Board over the past 50 years. I thank the current board that has increased the number of registered engineers from 450 to 1,225 in the last five years. The country needs more registered engineers to implement projects in infrastructure development, which currently account for more than 20% of the national budget.

I take this opportunity to thank the chairman, the entire ERB and the publications committee for the vision to start and facilitate this journal as a premier voice for communicating important engineering information to develop the nation. I thank the authors, sponsors and advertisers who have provided the content in this journal.

I further extend my gratitude to the management of 8M Construction Digest, headed by Eng Hans JWB Mwesigwa, for their consultancy in publishing this special edition.

It is therefore my distinguished privilege to unveil this golden jubilee edition of The Engineer.

I wish the readers a merry Christmas and a prosperous new year 2020.

For God and my Country

Monica Azuba Ntege
MINISTER OF WORKS AND TRANSPORT

MINISTRY OF WORKS AND TRANSPORT

The Minister and entire Staff of the Ministry of Works and Transport congratulate The Engineers Registration Board and the Engineering Fraternity on their Golden Jubilee (1969-2019)

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A message from Chairman, ERB

Dear reader, as we mark the 50th anniversary of the founding of the Engineers' Registration Board in December 1969, it gives me great pleasure as the Chairman of the Board to heartily congratulate Ugandan engineers for this milestone.

The profession has grown and matured in the intervening years since 1969. Up to 8 universities now offer myriad of courses in engineering starting from Makerere in 1970. They collectively churn out about 2000 graduates per year. The quality of teaching competes favorably internationally with Ugandan trained engineers making marks both locally and internationally. The Board, as the competent authority in Uganda, has contributed to this growth by participating in the accreditation process for university courses that had seen growth in numbers of engineering graduates. As a regulator, the Board has ensured that standards and quality associated with practice is upheld and grown. Today Ugandan engineers dominate practice and provide leadership at top echelons of Government and Private sectors. There is less reliance on foreign expatriate engineers by the profession. Working together with Uganda Institution of Professional Engineers, the Board has seen to growth in number of registered engineers to 1,225 to-date. The most growth occurred in the last five years when numbers escalated from 450 in 2014 to 1225 today.

These registered engineers provide the bedrock through whom the Board discharges its mandate. They are a pool of manpower for satisfying demand for local engineering skills by the industry. They train upcoming engineers and the Board deploys them on contractual arbitrations and delivery of technical advice as necessary.

The board has also extended its international outreach and relationships; it is a signatory to the East African-wide Mutual Recognition Agreement (MRA) with partner competent authorities of Kenya, Tanzania, Rwanda, Burundi. There is an MoU with Egyptian Syndicate of Engineers (ESE) targeted at capacity building and benchmarking of practice. In the same vain, the Board continues to work with competent authorities around the world for temporary registration of foreigners who come to practice in Uganda.

Over the years, the board has faced many challenges that have impeded its work. Quacks continue to invade our space with calamitous results on public safety. The Board's resource base is narrow and available budget cannot finance capital investments. The Board is yet to acquire a permanent home. The growth in numbers on the register is still low compared to other sister MRA authorities. At a ratio of 1:30,000 people, the per capita ratio of engineers in Uganda pales in comparison with international standard of 1: about 1000. A lot of times, public perception and policy decisions disfavor engineers, thus crowding them out of rightfully deserved positions of responsibility.

To address these challenges, the board has launched a number of initiatives in the last few years. For a start, moves are under way to revise the founding law, the ERA Act of 1969 to fully empower the Board to fulfill its mandate. Land has been acquired at Namanve Industrial Park to build ERB premises. Funds are being sought. Working arrangements and MoUs are in place with UIPE and National Council for Higher Education (NCHE) to regulate quality of university teaching, capacity building and registration of engineers.

The board is working on a five year strategic plan to drive its performance in the next five years.

I salute individuals and persons who variously constituted membership of ERB Boards and secretariat in the last 50 years for the great work done in nurturing the profession. Ministry of Works and Transport has done exceptionally well in providing policy oversight to the Board in the period. I thank members of the current 17th Board for organizing celebrations to mark the 50th anniversary of ERB as well as the annual Engineers Forum 2019.

As we look towards the next 50 years, it is imperative that we recognize that science and engineering will greatly dominate progress of civilization such that we as a profession should research and innovate to match that progress. While we now talk of the 4th industrial revolution, in the next 50 years, this will transit to 6 or 7th industrial revolution with phenomenal explosion in vast computing powers bringing forces of nature more and more within control of mankind. We should be ready. I urge government and the public to accord more support to the profession so as to prepare it for the next digits years.

Merry Christmas and Happy New Year.

Eng Dr Michael Moses Odongo
Chairman, Engineers Registration Board

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A message from **Registrar, ERB**

The Engineers Registration Board (ERB), established under the Engineers Registration Act, 1969, Cap 271, is a statutory body to regulate and control engineering practice in Uganda, continuously improve the engineering profession and advise Government accordingly. For the last 50 years, the Registrar has kept and maintained the register which contains all names of persons formally accepted by ERB as entitled to use the prefix "Eng" before their names. The registrar also publishes in the Gazette on an annual basis the names of all persons that remain on the register and are legally accepted to practise engineering in Uganda. The current registrar is the ninth Registrar of ERB and was appointed on 1st February 2016 and has steered the 16th and currently the 17th board. As ERB celebrates its golden jubilee, the register has grown to 1,225 engineers as of December 2019. A total of 465 engineers have been added to the register in the last five years up from 763 in December 2014, which accounts to 37.8% of the total registered engineers.

But who qualifies for registration in Uganda under the ERA Act 1969? As detailed on our website www.erb.go.ug, we register persons who hold a Bachelor's degree in engineering or its equivalent from a recognized university. To be eligible, they should have undergone two years of postgraduate pupillage and an additional two years of practice under a registered engineer. A career report and technical report normally accompany the application. We recognize registration from the countries of the East African Community through the Mutual Recognition Agreement (MRA), and some Commonwealth countries.

As the board marks the 50th anniversary, an amendment to the founding Act of 1969 has been sought by the engineering fraternity. One would wonder: Why the need for the Engineers Registration (Amendment) Bill 2018? In summary, the proposed amendment is to provide for mandatory registration for practising engineers, provide for replacement of the Engineers Registration Board with the Engineering Council, to provide for allied professionals and semi-professionals, establishment of a full-time secretariat and to provide for an annual practising licence for all professionals governed by the Act. The amendment will majorly cure regulation and registration of the technologists and the technicians who hitherto were not considered by the founding act despite the fact that they provide the bedrock of all engineering works. It shall further provide for a full-time registrar who shall be the chief executive officer responsible for the day-to-day operations and administration of the council. To date, the amendment is at the level of the First Parliamentary Counsel under the Ministry of Justice and Constitutional Affairs for final drafting before it makes its way to Cabinet and later Parliament.

Another notable achievement of the board as we celebrate the golden jubilee is the acquisition of two acres of land in Namanve Industrial Park for the construction of the Engineers Tower. The proposed facility will contain a range of technical facilities for use by the engineers and the public at large. The technical facilities will include a skills development and innovation centre, an advanced engineering laboratory, ERB offices, a conference hall, and an exhibition hall.

As we celebrate 50 years of the Engineers Registration Board, we call upon all engineering graduates to register with ERB and legalise their practice. It should be noted that during the last four years, the registration process has been streamlined with synchronised assessment by the Engineers Registration Board and the Uganda Institution of Professional Engineers. Therefore as we present ourselves for active participation in the Fourth Industrial Revolution, we should have a pool of professionally registered engineers to benefit our country Uganda as we move forward.

Its my pleasure to launch the golden jubilee special Journal

Eng Ronald Namugera
MSc,MBA, BSc, MCIHT, MUIPE, REng
Registrar Engineers Registration Board

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The Office of the Auditor General, congratulates the Engineers Registration Board and the engineering fraternity upon celebrating their 50th Anniversary (1969-2019)

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The Engineer in the Fourth Industrial Revolution

Introduction

The Engineers Registration Board (ERB) of Uganda is organizing an engineers forum to be held in Kampala, Uganda, at Hotel Africana from ***5th to 6th December 2019***. The forum's objective is to share and disseminate experiences, engineering knowledge, plans, readiness and solutions targeted at the 4th Industrial Revolution (4IR). The forum also culminates into the Board's celebration of its **50 years** since its establishment in 1969.

The forum whose theme is: ***"The Engineer in the 4th Industrial Revolution"*** will bring together professionals of different engineering disciplines, researchers and academia.

What is industrial revolution?

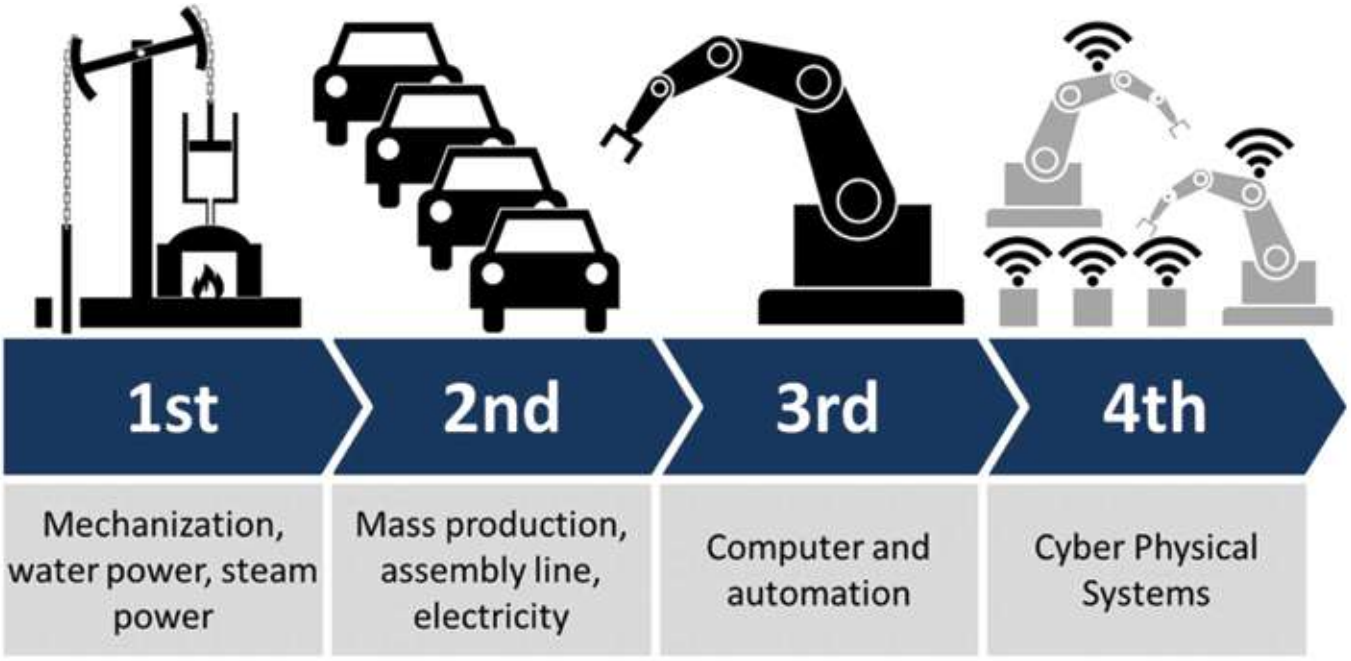
Industrial revolution is defined as the changes in manufacturing and transportation that began with fewer things being made by hand progressively being realised using machines in larger-scale factories. The Industrial Revolution was a period of major changes in manufacturing and trasnportation that took place during the late 1700s and early 1800s. This period saw the mechanization of agriculture and textile manufacturing and a revolution in power, including steam ships and railroads that changed the social, cultural and economic conditions.

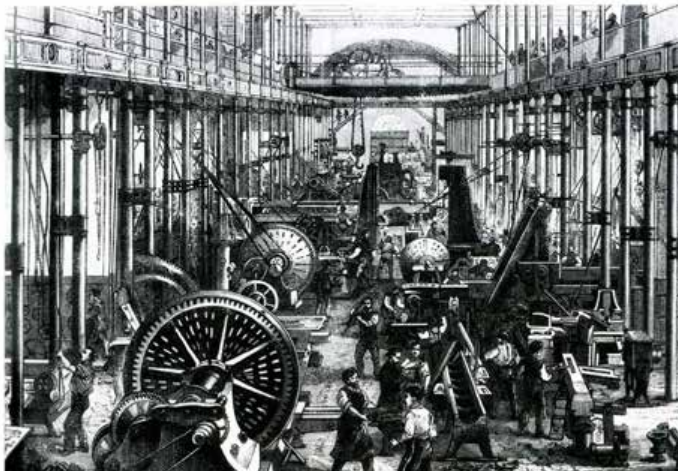
First Industrial Revolution

The first wave of the Industrial Revolution lasted from the late 1700s to the mid-1800s. It industrialized the manufacture of textiles and began the move of production from homes to factories. Steam power and cotton gin played an important role in this period.

Second Industrial Revolution

The Second Industrial Revolution was said to be between 1870 and 1914, prior to World War I. The main causes of the Second Industrial Revolution were due to: natural resources, abundant labour supply, strong government policy, new sources of power, railroads and American inventors and inventions.





2.3 The Third Industrial Revolution

Nearly a century later, in the second half of the 20th century, a Third Industrial Revolution appeared with the emergence of a new type of energy whose potential surpassed its predecessors: nuclear energy. This revolution witnessed the rise of electronics — with the transistor and microprocessor — but also the rise of telecommunications and computers. This new technology led to the production of miniaturized material which would open doors, most notably to space research and biotechnology. For industry, this revolution gave rise to the era of high-level automation in production, thanks to two major inventions: automation and robots.

2.4 The Fourth Industrial Revolution (4IR)

This Fourth Industrial Revolution is, however, fundamentally different. It is characterized by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries.

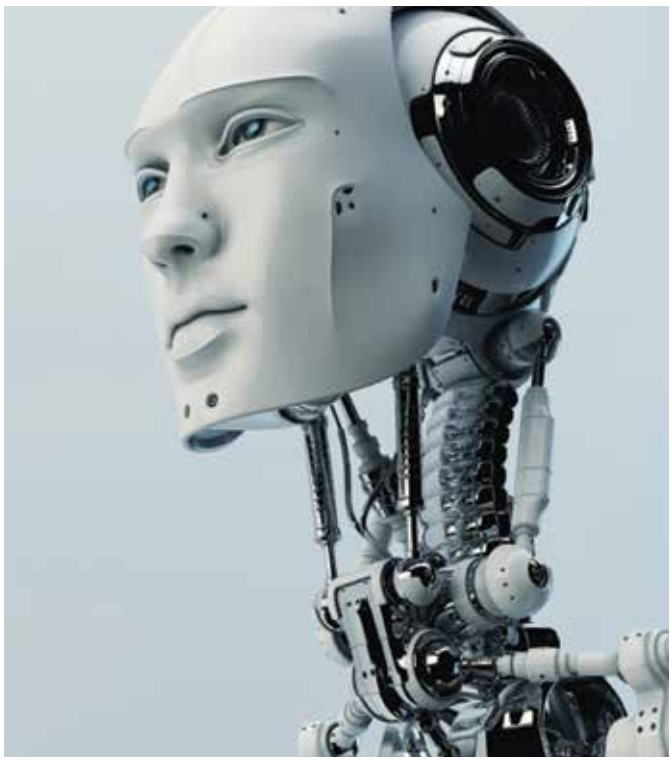
One may define the 4IR as the pertaining and developing environment in which we find ourselves being either augmented or disrupted by technologies and trends changing the way we traditionally live, relate and work. Such technologies include Artificial Intelligence (AI), Virtual Reality (VR), Internet of Things (IoT), Robotics, Mobile Internet, Cyber security, BlockChain, 3D Printing, Wireless Power, Quantum Computing, 5G, Autonomous Cars, Voice Assistant, Cloud and the like.

Why the theme: "The Engineer in 4th Industrial Revolution?"

The 4IR has already arrived and will continue to change the way we live, relate and work. We are facing a range of new technologies that combine the physical, digital and biological worlds. These new technologies will impact all disciplines, economies and industries and even challenge our ideas about what it means to be human.

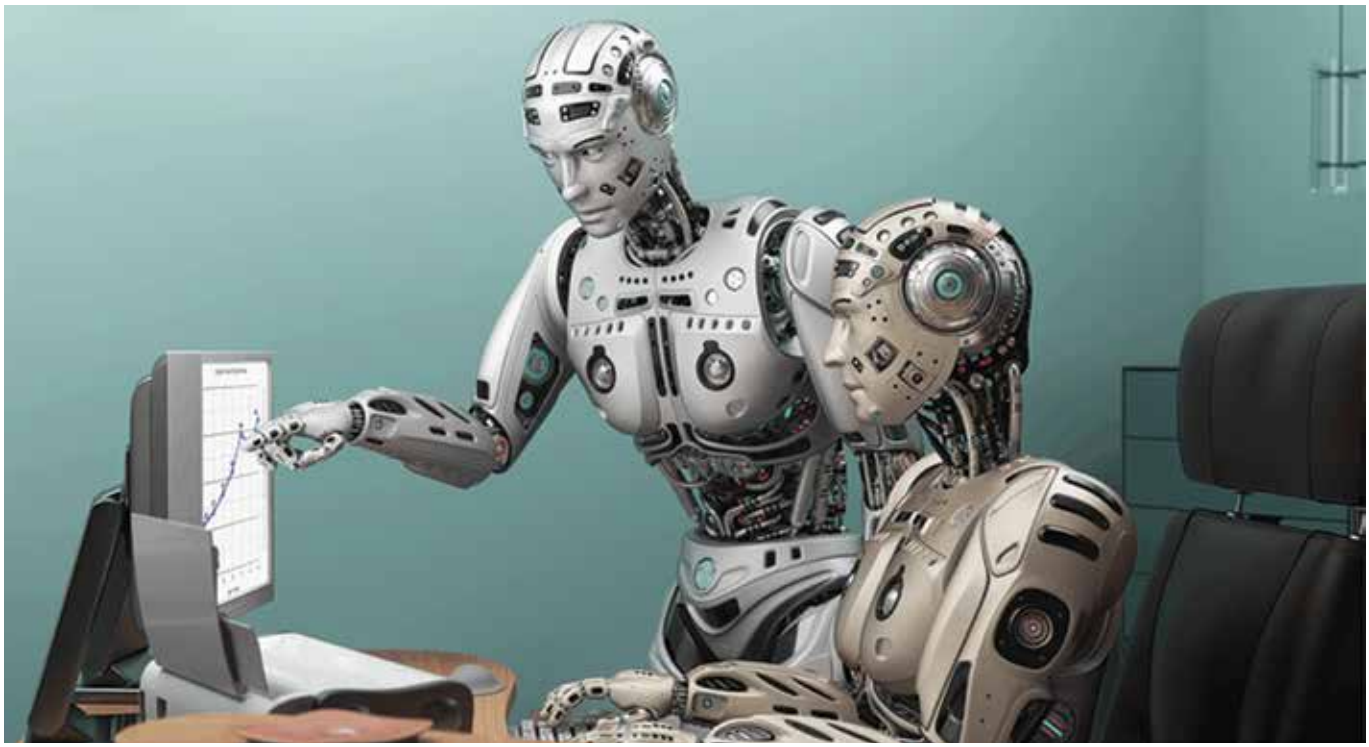
"I am very honoured and proud of this unique distinction. This is historical to be the first Robot in the world to be recognized with a citizenship," said Sophia, the AI Humanoid Robot, announcing her new status during the Future Investment Initiative Conference in Riyadh, Saudi Arabia, in October 2017. Sophia, "maturely born" in Hong Kong in 2016, is a Saudi Arabian citizen, with a passport and was granted a visa by Azerbaijan while attending the Global Influencer Day Congress held in Baku in November 2018.

There are also grave potential risks of being unable or unwilling to adapt these technologies or failure to properly regulate them, which would result in



inequalities, security and social concerns. The theme was selected with these challenges in mind and also in line with the objective of the national task force composed of a team of experts to guide the country on the fourth Industrial Revolution.

Therefore, the forum will provide an opportunity for interaction and sharing of experiences across the different engineering disciplines with the view of providing engineering solutions that do not only guarantee survival in the 4IR but also are prepared to harness its benefits.



A reality check on Sub-Saharan Africa's stage in the Industrial Revolution

By Eng Kant Kanyarusoke and Eng N E Nteka
Department of Mechanical Engineering,
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of Technology, South Africa

Kant Kanyarusoke (KK) received a First-Class Honours BSc. in Mechanical Engineering of Makerere University in 1982, an MSc Mech. Eng. of the University of Lagos in 1985, a cum laude Higher Diploma in Higher Education and Training, of CPUT in 2009, and a Doctor of Engineering degree of CPUT in 2017. Furthermore, he has an ESAMI CIRDAFRICA PG certificate in integrated rural development. He is an ASHRAE and SASEE member. He currently teaches undergraduate and postgraduate mechanical engineering students at CPUT. With 37 years, largely concurrent, university teaching and industrial practice experience in Eastern and Southern African universities and manufacturing companies, Dr Kanyarusoke prides himself as a pan-Africanist engineering Pracademic. His current research interests are in solar energy engineering and in transformative engineering education for Sub-Saharan Africa. He has won several international awards, especially in research and development of solar energy systems for rural areas.

Abstract

This paper presents the first part on work explaining an approach to industrialisation of Sub-Saharan African (SSA) countries. It gives the theoretical basis of a practical approach suggested in part 2 of this work, making a quick review of conditions that facilitated industrialisation elsewhere, and relating those to realities in present-day Sub-Saharan Africa. We find that the most important lessons for the region are in the technological, economic and political arenas. Key strengths include a large youthful population, a large land mass, sizeable energy resources, fresh water, minerals, flora and fauna, fertile soils and even sandy desert lands with clear skies. Weaknesses include irrational political fragmentation, a multiplicity of poorly managed currencies, corruption, and most importantly, a largely science-technology-engineering-maths (STEM) illiterate population, leading not only to local self-doubt and confusion, but also to a perpetuation of foreign dependence. Recommendations are made in these areas to ease entry into the industrial revolution. The most important recommendation is 'massification' of local production and consumption through low technology industrialisation, mixed with steadily rising levels of higher technologies that match the rising proportions of local sophisticated customers. This raises the question of how to enter the revolution at several fronts: an issue we tackle in part 2.

Key words: Africa industrialisation; the industrial revolution; Sub-Saharan Africa

Introduction

Indira Ghandi advised: "Be the change you want to see in life" (Edberg, 2019). This thought-provoking statement stems from the fact that we live in a dynamic space-time environment rather than in static space. Human societies are therefore in a state of flux. Slower changes are recognised as 'evolution' but faster ones are revolutionary. A revolution in one aspect of society is therefore a rapid change in the way that aspect manifests itself. 'Rapid' here means that the change occurs within less than a generation, so that specific human age groups can notice and participate in it.

The greatest revolution in modern human history is thought to be the Industrial Revolution (IR) which started in England in the mid-eighteenth century (Allen, 2009). It was a man-made revolution in which production of commercial goods was changed from artisanal to mechanical in centralised areas called factories. The machines produced tens to hundreds of times faster than skilled artisans could do, and thus consumed lots of raw materials in a given time (Wrigley E A, 1962). Moreover, they required lots of energy and water supply to run. Thus, factories sprouted up in areas along navigable rivers, and preferably close to sources of fuel. Machines could not tire like human artisans. They could therefore run 24/7 if required. Although they replaced skilled artisans, they still needed people to operate them in shifts, but this time, two kinds of labour were required: the unskilled – to do routine repetitive and manual work, and the more skilled, to supervise the former, manage the production lines, and maintain the machines. Thus, the revolution had both qualitative and quantitative effects on labour requirements, which

led to massive rural to urban migration and rapid development of cities.

From its epicentre in England around 1760, the revolution spread to the rest of the world and transformed it as shown in Table 1. Approximately three centuries or 10-15 generations later, it is only on the African continent, particularly in the region south of the Sahara that the revolution has not yet spread to significant levels except in isolated centres of modernity like Cape Town, Johannesburg, Lagos and Nairobi. Yet this is not to say that Sub-Saharan Africa has not been impacted by the revolution. Initially, as a supplier of slave labour to the Caribbean islands and the Americas to grow sugar cane, cotton and tobacco for the raw materials-thirsty British factories in the infamous Triangular Trade (Findlay, 1990), it was. Later, in the last quarter of the 19th century, as the revolution spread to continental Europe, the steep-step change and exponential increase of demand for raw materials meant that their supply chain had to be shortened and made even cheaper. Moreover, Great Britain had at that time already enforced a world-wide stoppage of slave trade across the seas. Thus, at the 1884 Berlin Conference, the initially slave-supplying Africa was parcelled out to industrialising Europe principally to supply both old and emerging factories with raw materials. Sub-Sahara African societies therefore forcibly became part of the supply chain of Europe's Industrial Revolution principally at its lowest value end, growing cotton, tobacco, tea, coffee, cocoa, rubber, etc.: products they had never needed for their own survival and wellbeing.

The higher end of the value chain of the Industrial Revolution was realised in Europe. It provided massive employment and greatly improved European standards of living. More importantly, as the revolution spread to other continents, especially North America and Japan, it sparked an exponential multiplier effect in scientific discoveries, engineering innovations, creativity, and technological, manufacturing and marketing breakthroughs. In these developments, it metamorphosed through different overlapping stages. So far, four of such stages can be identified whether in terms of time or of energy sourcing or of countries joining the main activity of manufacturing. Table 1 summarises this metamorphosis.

Table 1: The four stages of the Industrial Revolution

Stage No. and period	Countries joining	Main defining activities in the stage	Energy sourcing and transformation	Participation by sub-Sahara Africa
1. 1750-1850	Britain leads; Belgium, Germany, USA, France follow later	Cloth making ceases to be a home-based, cottage industry done by skilled hands. It is now done by a series of invented machines in factories.	Water and steam power are unleashed to replace horses. Iron replaces timber as main engineering material; Coal replaces charcoal as fuel and as primary source of iron ore reductant.	Africa supplies slave labour on plantations in the West Indies and America as part of Britain's triangular trade
2. 1850 -1914	Portugal, Spain, Italy, Australia, Soviet Union and Japan join. Germany and USA overtake Britain as world leaders in inventions and manufacturing	Communication is revolutionised through steam powered locomotives and extensive railway networks. Telephony comes on the scene; Advances in chemistry lead to fertiliser and pharmaceutical factories	Electricity is discovered. Steam power plants powered by coal and by petrochemical oils generate electricity. Steel replaces iron as the main engineering material. The internal combustion engine comes on the scene, and the automobile revolution begins. Manned flight starts.	Africa supplies low value agricultural raw materials to colonial European powers. A small elite group of Africans forms a nucleus of captive markets for products from factories in respective colonial powers.
3. 1914 –1970	Brazil, Korea, Turkey, Iran, Israel, South Africa join. USA emerges as supreme leader in engineering innovation, followed by the Soviet Union.	Analog and digital electronics in industrial controls. Robotics comes on the scene. Industrial Engineering and Management come of age. Computers are introduced. Space race and a cold war between the two world super powers get going.	Fossil fuels bloom. Nuclear energy comes of age. Fuel cells appear. Photovoltaic electricity finds use in space missions.	Africa's supplies of raw materials diversify to include minerals, crude oil, and flowers. A few agricultural produce-processing factories begin to appear in some politically independent countries. Multinational manufacturing companies from former colonial powers begin to appear.
4.1970 to date	China, India, United Arab Emirates join. China takes lead as the world's No. 1 manufacturing and civil engineering construction centre.	China sets up millions of cottage manufacturing centres, lifting over 700 million people out of poverty. India re-industrialises, this time using machinery, and uses internet and satellite communication to service manufacturing centres in more advanced countries. Supply chains integration using internet begins.	Renewable energy sources of energy begin to enter the extended supply chain energy mix. New engineering materials in form of composites, nano-materials and genetically engineered biomaterials gain significance.	Africa continues to supply raw materials, this time to an enlarged manufacturing world that includes China and India. Consumption trends shift to goods and engineering services provided by China. Some multinational companies from previous colonising countries wind up manufacturing in some of the African countries.

It can be seen from Table 1 that Sub-Saharan Africa is yet to participate significantly in the Industrial Revolution at higher-value levels. But many current discussions at government levels and in universities gravitate about the continent joining the revolution as a significant beneficiary at level 4, alongside China and India. There is talk of 'leapfrogging' all the other stages, in transforming largely subsistence peasantry populations to modern industrial ones with sizeable middle-class components within less than a generation. Is this realistic? If possible, how can it be facilitated? And if not, what is it that needs to be done by the affected countries to achieve realisation? This paper addresses these questions by examining how representative countries in column 2 of Table 1 managed to industrialise. Later, we make a snapshot look at the continent, determine constraints to its industrialisation, and suggest a way forward.

The enabling factors

Wherever the Industrial Revolution found root in form of manufacturing, there were predisposing conditions for it. Some conditions repeated themselves in different countries but others were unique to specific societies. Table 2 is a summary of these factors.

Table 2: Summary of IR-enabling factors and key actions in major industrialised countries

Country/ Region	Enabling factors and actions
England (UK)	• Geography – Protected Britain from attacks of unsteady Europe; Availed fresh water, cheap coal, rich and numerous iron deposits, navigable rivers. • Political stability and direction - Progressive monarchy since 1689 unified Britain, eliminated intra-country trade barriers, attracted intellectuals from elsewhere, rewarded hard work • Prior Science and Agricultural revolutions – availed enough food and multiplied population; moved population off the land to seek employment in upcoming industries. Protestantism nurtured and rewarded hard scientific work.
Europe	• Iron and coal deposits in Belgium, Germany • Permissiveness to accept and absorb useful migrants from elsewhere, especially Britain • German peoples unification and elimination of internal trade barriers • Exploiting war's urgency for frontline solutions by Napoleonic France • Emphasis on STEM education particularly in Germany and France
USA & USSR	• Geographic size and natural resources (USA & USSR) • Emphasis on STEM education, preferential migrations of STEM gifted persons • Exploiting creative political-military rivalry
Japan	• Political direction and unification of Japanese market in the Mejji era • Unrivalled Mathematical education and aptitude in prior era • Confucianism philosophy led to unchallenged authority to steer the country positively • Openness and purposeful adoption of foreign ways of doing things and massive recruitments of European staff • Positive exploitation of opportunities provided by America's gun boat diplomacy
China	• Confucianism and political direction through meritocracy • Population size irrespective of its level of development • Positive exploitation of external threats as forced onto China by Britain's gunboat diplomacy in the opium wars • Concretised the scientific path to rapid industrialisation from extreme rural agrarian poverty • STEM education emphasis and rewards
The Tigers (Korea, Taiwan, Hong Kong & Singapore)	• Confucianism and political direction • STEM education emphasis • Positive exploitation of unique geographic advantages (Hong Kong and Singapore) • Proactive government participation in industrialisation

Key summary lessons for industrialising SSA

In this section, we use lessons drawn from the above sections and part of an earlier study on engineering entrepreneurship in Africa to comment on SSA's industrialisation from political, economic and technical perspectives.

Industrialising Africa

Kanyarusoke (2019) summarised key challenges faced by engineering entrepreneurs on the continent, in form of a PESTLE scan. Industrialising Africa will have to address these issues irrespective of whether it is spearheaded by governments or by private individuals. Here, our comments on SSA's IRs will focus on the political, economic and technical aspects of the PESTLE scan.

Required political actions

In all the countries in Table 1 and Table 2, political stability was a prerequisite. Even where there were violent political upheavals as in France and USSR, strong-willed and competent leaderships stabilised the countries in question before industrialisation started. It did not matter whether the stabilising leadership followed a 'western' form of democratisation (USA), a 'command' type of orientation (USSR) or even a politico-militaristic stance (France). What mattered was whether the leaders were enlightened enough to marshal national support, initiate, and implement policies to ease business in the country. This means that African leaders need to focus more on the stability of their nations and not necessarily the debates on what form of governments they lead. The bottom line is that their actions ease business in the countries.

A key political issue in the scan was the irrational fragmentation of Sub-Saharan Africa into many small-economy countries. The lesson from the industrialised countries is that industrialisation means mass production of industrial goods, and that this mass production is only possible if it is for a mass market connected to the production centres with a seamless transport infrastructure and human migratory system. This means that present-day African leaders must work to dissolve the fragmentation and fuse some countries together. The resulting fewer countries ought to open their new economies for trade with their new immediate neighbours. We also learn that because high-level STEM brainpower ability is normally thinly distributed in pre-industrial societies, countries needed to attract (Britain, Belgium, Japan, USSR), steal (USA, France, China, Italy), retain and even naturalise (USA, Canada) specially gifted persons irrespective of their origins. For Africa, present-day politicians and leaders ought to be working hard to stop current incidents of racism, xenophobia, tribalism and other forms of irrational prejudice while actively seeking to attract STEM-gifted persons from wherever else to their countries. On this 'brain poaching', there should be no self-restraint by enlightened leaders because it would be best for at least one country to demonstrate to neighbours what a high and broad-based STEM endowment can achieve. Moreover, poaching from within Africa could most probably lead to greater cross-cultural understanding and ease continental integration.

Addressing economic challenges

SSA's commonest economic challenges include: limited financing for capital and recurrent expenses whether in public or in private sectors; large fractions of populations simply subsisting in informal parts of economies with only small fractions in the formal sectors; and corruption, especially in the relatively overstaffed and ill-equipped public sectors. Looking at the industrialisation in

many of the countries discussed above, we submit that the issue of financing in SSA could be realised first by encouraging all people to convert resources before them using the means immediately available to them into locally saleable products, thereby monetizing the labour they expend in the conversion. This, in our view, settles the supremacy debate between labour and capital in present-day African economies. For the economies are well supplied with labour but they are undercapitalised. The point is that if expended labour is monetised and rewarded accordingly, people develop consumerism, making individual or cooperative entrepreneurs among them grow capital, thereby capitalising the economies. This means capital grows out of labour, and is therefore subordinate to it.

Many African governments have tended to focus on export-led growth economics e.g. Namibia (Jordaan & Eita, 2007). This is a situation where they encourage their nationals to produce what they think they can produce primarily for foreign markets in expectation of increased foreign currency earnings to import goods whose production is currently out of their reach. Popular as this approach may be, we have issues with it. Firstly, as pointed out (Rodney, 1973), this is simply another way of perpetuating the unfair trade system of colonial times, where African colonies were forced to produce low-value raw materials for industrialising colonial powers, as their small elite leaders became an appendage market of foreign industrialist high-value products. The bulk of the population are left out of the market, only participating in forced supply of labour for raw material production, and hence, struggling to subsist if the concerned raw material is not a food crop/item. Moreover, even where the item is a food, such as fish in Uganda, beef in Botswana, or cashew nuts in Tanzania, etc., the very best is reserved for foreign markets while only the least-quality product is for local consumption. Secondly, and most importantly for Africa's industrial revolutions, the approach denies African engineering entrepreneurs the absolutely essential early learning stages in the evolution of engineering skills, product development and growth. Recognising these problems, some African countries like Kenya have adopted import substitution strategies, encouraging industrialists to manufacture goods for the elite leadership locally. This is the manufacturing equivalent of the often despised political practice of replacing European colonial administrators with local ones, without changing the fundamental political economy of newly independent countries (Dini, 2017).

White Masks is a merciless exposé of the psychological damage done by colonial rule across the world. Using Fanon's incisive analytical abilities to expose the consequences of colonialism on the psyches of colonized peoples, it is both a crucial text in post-colonial theory, and a lesson in the power of analytical skills to reveal the realities that hide beneath the surface of things. Fanon was himself part of a colonized nation - Martinique - and grew up with the values and beliefs of French culture imposed upon him, while remaining relegated to an inferior status in society. Qualifying as a psychiatrist in France before working in Algeria (a French colony), Fanon saw a country subject to brutal repression. In either case, the interests and consumption needs and abilities of the majority non-elite are ignored. Japan, China and the Tigers' examples above show us that the more appropriate approach would be not simply to transfer product manufacturing but motivate the design, development, manufacture and mass marketing of a range of products covering the full range of IRs as mapped to the different disposable income segments in respective countries.

Addressing technical challenges

Without a doubt, technical challenges are the greatest impediment to industrialisation on the continent. They range from extreme shortage of STEM and management skills to infrastructural inadequacies. However, prior to colonialism, appropriate artisanal work or technical skills existed throughout the continent before colonies started. It included carpentry, boat-making, iron smelting and metal working, cloth making, among many others (Rodney, 1973). Training in specific trades was compulsory both formally and informally with no room for failures. This traditional universal skilling system was destroyed in the colonial era and was replaced by a tiny formal educational system that was initially intended to train local clerical and administrative support staff for colonialism. Post-independence technical education in many countries took the form of single university training in engineering, without regard for the necessary balance of numbers between the various work levels in the profession.

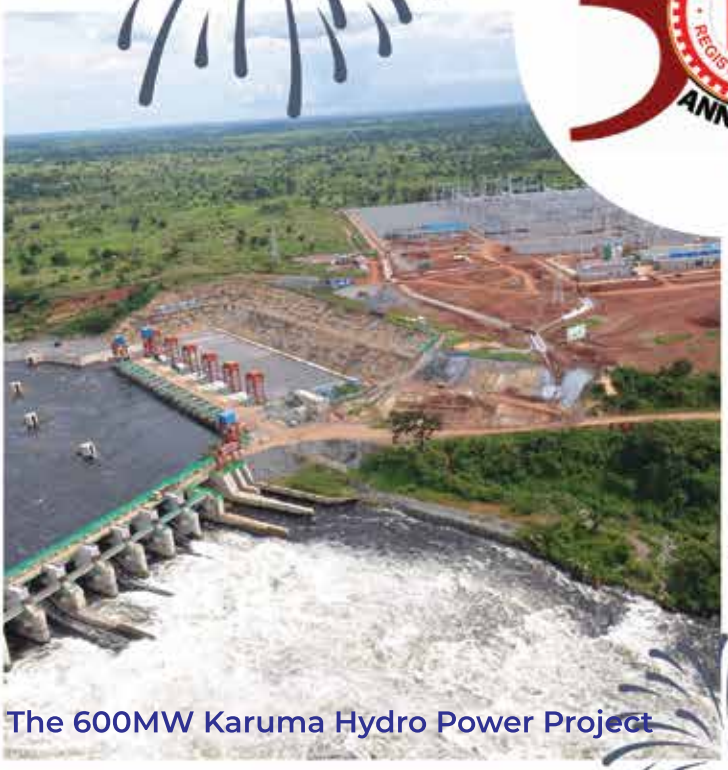
Today even as the Fourth Industrial Revolution is on in the world, what is required of African countries is to popularise STEM education by diffusing it throughout the population, like India and China did. We further recommend affirmative rewarding of people selecting to work in STEM-related professions. Additionally, this should be supplemented by attractions of similar professionals from elsewhere as explained in the political actions section above.

At university level, we note the inadequacies in practical skill developments and a virtual absence of studies on the history of technology and how technologies evolve with developments in the societies they serve. Also, studies on Reverse Engineering are missing. This makes maintenance, copying and adopting foreign developed technologies more difficult – as we notice in today's import substitution industries mentioned in the economic challenges above.

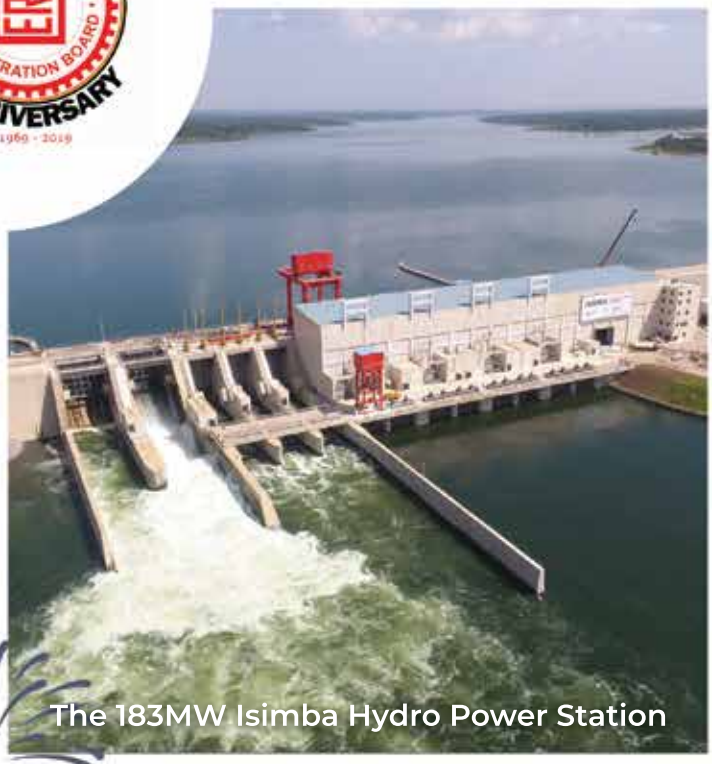
We recommend an urgent attention and correction of these problems if Africa is to rely on its future engineering human resource to industrialise. It is acknowledged that universities generally lack the necessary practically skilled staff to effect changes as we are suggesting. The possible solution to this shortcoming is a closer cooperation between industry and faculty through use of industry-based guest lecturers and a purposeful regular secondment of faculty to industry for periods long enough to enable them gain greater insight into the realities of engineering practice. A

CONGRATULATIONS ERB

50 years of regulating the engineering profession is worth a toast.
Here is to more celebrations with the ***generations*** to come



The 600MW Karuma Hydro Power Project



The 183MW Isimba Hydro Power Station

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more radical approach would be for universities to base their engineering faculty recruitment and promotional policies on previous or current engagement in industrial practice.

Leapfrogging technologies

Finally, let us address the issue of leapfrogging technologies to join the Industrial Revolution at later stages. There can be advantages and issues with expectations of SSA industrialising at higher phases of the IR. The clearest advantages include avoidance of obsolete technologies that have long been replaced by newer, safer, more effective/efficient, and sometimes, less costly alternatives. Replacement of external combustion engines (e.g. steam locomotives) by internal combustion ones (diesel/petrol/gas engines) and subsequently of the latter by electric traction systems in the second and third IRs are good examples. So are replacements of telephone landlines by mobile cellphones and smart phones in the third and fourth phases. The controls and data handling capabilities of the Fourth Industrial Revolution can enable many people even with limited technical and administrative skills to interpret and use otherwise complex systems such as smart homes, e-government and interconnected schooling. Moreover, the numbers of highly skilled persons required to provide services or products otherwise given through these systems are small. This might seem to be advantageous to SSA where such numbers are already small. Yet there are numerous reservations in hoping for a wholesale adoption of higher level IR phases as a realistic way of this region 'catching up' with countries that industrialised at earlier stages. The most obvious weakness of this expectation is that it is a continuation of the long established 'rich producer/technology owner'-'poor consumer' relation between SSA and the advanced economies. The second point of departure is that in so far as it excludes most of the people from the supply side of the value chain, it limits their technology development just as the popular and extensive use of calculators from the time of the Second Industrial Revolution or the extensive use of computer simulations to visualise and solve engineering problems in the third phase have tended to compromise the mental mathematical abilities and understanding of the problems of physics, respectively.

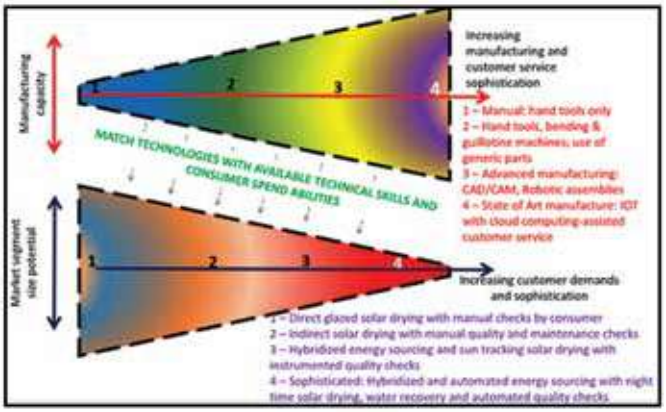

Figure 1: Making the Industrial Revolution phases meaningful in a typical product design and development

In the literature, it has been consistently argued, sometimes correctly, that new technologies in successive IR phases do create job and development opportunities that did not exist previously, thus uplifting and benefitting society sooner than would have been the case (Xu, David, & Kim, 2018). This may be true for either a largely literate population already participating in some forms of mass production and market systems (e.g. Germany and Japan cases above) or for a population that can be administratively forced into such systems (Britain at pioneering stage, Russia and China cases). It is debatable that entire SSA populations can be thought to fall in any of these categories at present. Rather, we find a mixture of relatively small proportions of educated/learned people with bigger proportions of less educated people largely in informal economy sectors as pointed out earlier. In such situations, our submission is that a mixture of technologies designed to be able to absorb different sections of the populations at their corresponding abilities on the supply side, while they are also matched with the different spending abilities on the demand side, is the appropriate way of entering the IR.

In a nutshell, SSA countries should not necessarily be thinking of leapfrogging some IR phases in their quest for industrialisation. They should adopt all the technologies and target them for specific market segments. Figure 1, which is an adaptation from (K. Kanyarusoke, 2019), illustrates this supply capability-market segmentation. While in that work, solar water heating is addressed, we think industrialisation in most of SSA can evolve, like in Britain, out of agricultural production. Then, we can have subsequent preservation, storage, processing, marketing and distribution of the produce – which activities - have the potential to pull all different population sections into formal economy sectors.

Conclusion

This part has looked at the industrial revolution and its four phases in other countries. We reviewed some literature on factors that favoured or delayed industrialisation in leading advanced countries. Industrialisation began in Britain, spread to Belgium, Germany, France, and then crossed the Atlantic into the United States. In Britain it followed political, science and agricultural revolutions, with the politics supporting a British imperial mercantile economy across the world. Early spread to other countries was mainly by industrial espionage, and in some cases by migration of engineering entrepreneurs. Japan's industrialisation followed gun diplomacy as the USA attempted imperialism on it. Russia industrialised later than Western Europe and Japan because the command economy targeted both agriculture and manufacturing. China, on the other hand, attempted several times to industrialise by copying what other successful countries had tried but it failed, until the last fifth of the 20th century. Its late success seems to concretise a possible recipe for industrialising largely agrarian populations. The steps sequencing seems to be: 1. Political stability,

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2. Rural farming commercialisation, 3. Rural produce processing, 4. Light industry manufacturing, 5. Heavy industry manufacturing, and 6. Integrated systems production.

A reality check in SSA was made. It was found that from slavery days through colonialism's deskilling actions to neo-colonialism's comparative economics doctrine, the region has continuously supplied labour, low value raw materials and a manufactured goods market to an ever-expanding external manufacturing base, keeping the populations in perpetual poverty. Large populations were outside the formal economies, a situation which even creates problems when trying to estimate sizes of the economies. The pure forms of both export-led and import-substitution industrialisation, as being attempted by some countries have been critiqued in so far as they ignore the majority of the populations. It is suggested that a better approach would be to use a range of technologies on any one problem that involve the different skills and income groups. An eight-step design and development process to exemplify such technologies in the area of crop-and meat-drying follows in part 2 of this paper.

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Gauff Consultants (U) Ltd, a member of the Gauff Group of Companies, is proud to be associated with the Engineers Registration Board (ERB) and warmly congratulates ERB as they celebrate 50 years of existence.

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Preparation of detailed designs, tendering, and construction supervision of the Katosi–Kampala Transmission Mains (2016-2020)

Gulu water supply and sanitation project (completed)

Kampala Water and Sanitation Programme Phase 1 – Component 3 Transmission Mains (completed)

Aswa Bridge (Completed)

Kingfisher access roads in the Albertine area 17 Km (completed)

Consultancy services for construction supervision for the upgrading of Kamwenge – Fort Portal Road 66.2 Km (completed)

Design review and construction supervision of the upgrading of Kigumba – Bulima Road Project 2015– 2020 (placing of Geotextile earth reinforcing membrane)

Design and construction supervision of Fort Portal Bundibugyo Lamia Road 103.6 Km (completed)

The Untold Story of ERB@50

By Eng Hans JWB Mwesigwa,
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Tel.: 0772431465

INTRODUCTION

A Spanish philosopher, George Santayana, once said, "Those who cannot remember the past are condemned to repeat it" (My emphasis: 'to repeat it', ie, the ugly part of history!) It is important for ERB and the engineering fraternity to know our history in order not to repeat the failures of the past! Of course, human nature makes all human beings repeat those follies, but it is better to try and fail than to fail to try to learn!

ERB IS BORN

In 1945, the East Africa Institution of Engineers (EAIE) was started to regulate and control engineers and their profession in East Africa. Recall that Uganda was then a protectorate while Kenya was a colony. Tanganyika then, which had been the larger part of German East Africa, had become a British trusteeship (Tanganyika Territory). The three countries gained independence in 1962, 1963 and 1961, respectively.

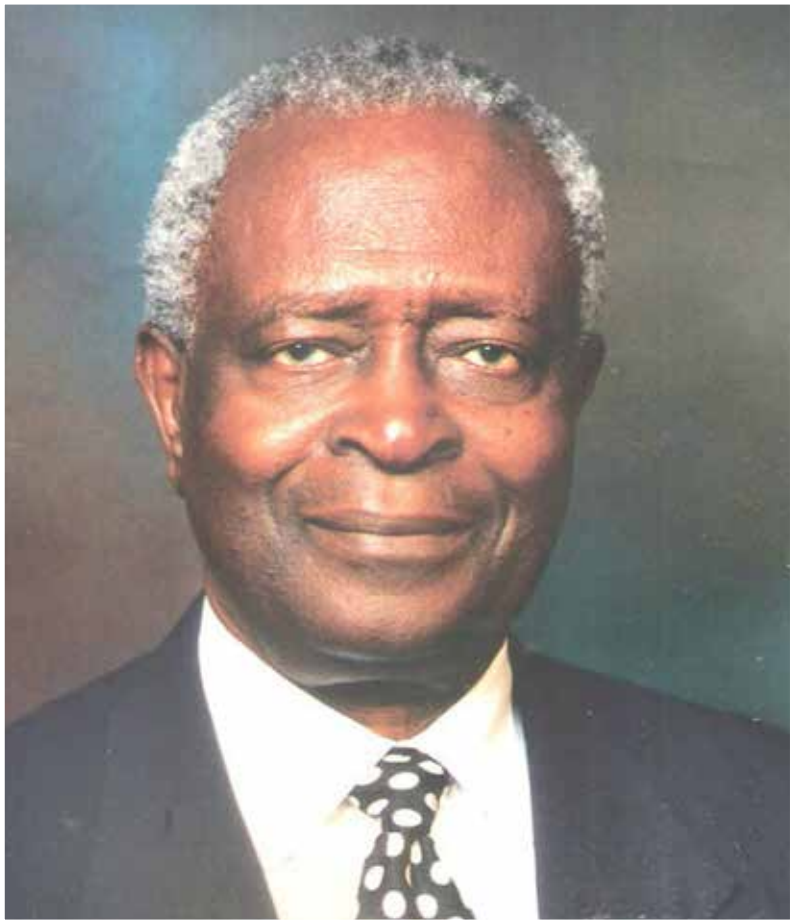
Political events affect everyone and everything. The independent countries decided that even the engineers must govern themselves in their respective countries. So, the Engineers Registration Act (ERA) of Kenya commenced on 5th September 1969. The Engineers Registration Board (ERB) of Tanzania was established in 1968. It was only repealed later when an ERA of 1997 was assented to by the then Tanzanian president Benjamin W Mkapa on 12th June 1997.

The Engineers Registration Board of Uganda was established on 1st December 1969 under the Engineers Registration Act (ERA) Cap 271, as a statutory body with a mission to regulate and control engineers and their profession within Uganda. ERA, which provided for the establishment of an Engineers Registration Board, defines its powers and functions and provides for the registration of engineers and matters connected therewith or incidental thereto. Further, the Act gave ERB wide-ranging powers to register, de-register, restore registration, suspend registration, hold inquiries, hear appeals and appear as respondents if a case is brought against it in court.

ERB started a process of revising ERA as far back as 2001. But as we went to press, this process had not yet been completed, for nearly 20 years! ERB feels that the Act, its 'mother', must be revised because it is outdated and has become too weak for the present more volatile environment. It is a toothless bulldog.

As an example, Chapter 30 in the 1969 Act on "Offences and Penalties" states, among others:

"(1) Any person who—.....without reasonable excuse, fails to register in accordance with section 20(5) or (6) [meaning the many unregistered engineers enjoying benefits of the registered ones!] or knowingly and willfully makes any statement which is false in a material particular, or which is misleading, with a view to gaining any advantage, concession or privilege under this Act, whether for himself or herself or for any other person, [meaning an unregistered engineer who claims to be registered whereas not and performs engineering works illegally] commits an offence and is liable on conviction to a fine not exceeding five thousand shillings. (2) Where a person charged with an offence under subsection (1)(c) is a body corporate, every person who, at the time of the commission of the offence, was a director or officer of the body corporate may be charged jointly in the same proceedings with the body corporate, and where the body corporate is convicted of that offence, every such director or officer shall be deemed to have committed the same offence unless he or she proves that the offence was committed without his or her knowledge or that he or she exercised all due diligence to prevent the commission of the offence."



The registered number one engineer (ERB No. 001) was Reverend Canon James Nyonyitono Zikusoka, a civil engineer then serving as the permanent secretary (PS) of the Ministry of Works, Communication and Transport.

In 2004, a commission of enquiry led by Eng Dr Jackson Mwakali as chairman and Eng Ben Ssebbuga Kimeze as secretary was carried out into the collapse of the NSSF wall on Lumumba Avenue, Kampala. There was loss of lives and fingers pointed at some professionals and entities who were involved in the design, construction and supervision of the works. In a turn of events, court threw out a case that sought to reprimand the 'actors' in the tragedy. It was understood that a weak ERA contributed to exonerating the accused.

From the above:

- Charging only Shs 5000 as a penalty for masqueraders of engineering is surely too small;
- A strengthened Act to 'catch' and punish culprits and employers who connive, employ or turn a blind eye to quark engineers is necessary.

ERA therefore needs urgent revision to strengthen the ERB and better the working environment of the engineering fraternity!

The registered number one engineer (ERB No. 001) was Reverend Canon James Nyonyitono Zikusoka, a civil engineer then serving as the permanent secretary (PS) of the Ministry of Works, Communication and Transport. Just like the incredible cosmos theory about the creation of the universe, we could not establish exactly the sequence of events that led to the appointment of the first ERB chairman, James Nyonyintono Zikusoka and his registration as number one. Until otherwise proved wrong, my research is as follows:

- A committee, headed by Zikusoka, the then PS was put in place to assist in the establishment and gazetting of the ER Act;
- The Minister, Hon Shaban Nkutu, used his powers to appoint the first board, chaired by Zikusoka with Eng W Dronyi as the first registrar. Eng G N Karugonjo was appointed secretary/deputy registrar and Eng G Oworaga as assistant secretary. Members were: Eng A P N Waligo, Eng Denis G Kabega, Eng A E Luba, Eng A S N Kiwana, Eng B S Knowles, Eng C Harris and Eng J S Crisfield.This specially elected caretaker board carried out special duties: it laid the foundation for a properly functioning board by registering registrable members so that they would register other engineers. Later the positions of secretary and deputy registrar were discarded in the second board of April 1971 to September 1972.

To date the latest registered engineer is 1,225. On average, therefore, ERB has been registering 24 engineers per year or two engineers per month. If this statistic is appalling, engineers may need to ask what happened and plan a way forward!

ERB IN THE GOOD, BAD AND UGLY TIMES

Completely airborne, ERB smoothly glided into the future, fuelled and propelled by the mother ministry, the Ministry of Works and Transport then.

The ministry provided all staff, premises and above all, the entire funding to sustain the operations. Records show that engineers, mainly from the Ministry of Works and Transport, the Ministry of Energy, and the Ministry of Water led the ERB. The Energy ministry boasted of the then Uganda Electricity Board, which had at its disposal men like Eng Abraham Waligo.

It is important to note that the Uganda Institution of Professional Engineers (UIPE) did not exist then. It was the ERB that planned and paved way for the start of this institution in 1972. The UIPE was established as an association of professional engineers of Uganda as a successor to the defunct EAIE, which had started in 1945. The objectives and purposes of the UIPE were and are still to promote the general advancement of the science and practice of engineering and its applications, and to facilitate the exchange

of information and ideas on those subjects among the members of the institution. Indeed, UIPE as per statute was started to professionalize engineers through training and enabling them to be registered.

The process of registration from 1970 to 1972 mainly hinged on the candidate's qualification and experience to satisfy the requirements of the ERA. An interview was then conducted. After payment of dues, the candidate was duly given a certificate of registration. So there were no assessment committees nor submission of technical reports.

Between 1972 when the UIPE started and 2000, registration was a two-way process: One applied and joined the UIPE as a fellow, corporate, graduate or student member on the basis of the prescribed qualifications and experience. Thereafter was an interview for the category of corporate membership, which was backed by a pass mark on a written submission about an engineering project in which the candidate had taken part. After this, the candidate at corporate level was declared "registrable". Thereafter, however, s/he would repeat the same process conducted by ERB in order to be registered.

From 2000 to date, a process whereby applicants are assessed through a Joint Assessment Committee (JAC) of the UIPE and the ERB has evolved. This is intended to enable all candidates who are admitted to "Member of UIPE" under this process to require the ERB to waive requirements of submitting another technical report and attending a board interview. They only apply for registration by filling ERB Form ERA 1, and attaching a Career Report and copies of certificates for the board's processing of the documentation.

Records from the archives at the ERB offices in Kyambogo show that the take-off was smooth, but the initial years were not a smooth ride. 1970 to1971 shows a steady registration of few but important engineers who were in high positions of responsibility. A glance at the list of board members at various times clearly shows heavyweights who enjoyed positions of ministers, permanent secretaries and heads of key government departments. The Amin era did not spare ERB which operated at a low ebb for obvious reasons. In a letter dated 7th March 1978, M W Wambwa, then the city engineer and surveyor of Kampala, wrote to the Ag Registrar of ERB, Eng Onzoma, acknowledging receipt of a circular letter that required several registered engineers to give details of payment of registration fees, then Shs300. After explanation, Wambwa added, "By the way, what has happened to the Registration Board? It seems it is no longer functioning."

ERB started a process of revising ERA as far back as 2001. But as we went to press, this process had not yet been completed, for nearly 20 years! ERB feels that the Act, its 'mother', must be revised because it is outdated and it has become too weak for the present more volatile environment. It is a toothless bulldog.

According to Eng Dr Katahoire, a Past President of UIPE and a former Board Member/Secretary (1987-1990), the ERB of 1970 to 1978 could not have fared any better because it had a small catchment area of registrable engineers, mainly from Nairobi. He reasons thus: The Makerere Faculty of Technology graduated the first batch of about 20 engineers in 1974 having started in 1970. These became registrable at the end of 1978. 1979 onwards, therefore, marks the period when it was conceivable to register an appreciable number of engineers.

In the 1990s, as Government privatized public organizations and parastatals, more private-based engineers felt less obliged to register. The ERB was predominantly run by academicians mainly from Makerere University and engineers based in government service. The Public Service gazetted key positions to be enjoyed only if the holder was registered. The weak ERA hardly punished masqueraders and quacks of engineers, many in the private or informal sectors.

The ERBs of the 2000 onwards have done a lot to register many, in spite of the weak Act that crucially needs amending. True, registration and subscription fees have increased tenfold or more, but the trend of expansion of membership is still low. The ERBs of the 1970s and 1980s did not involve themselves in other activities save registering. All training and mobilization was left to UIPE. The current trend, however, has been to undertake training and publishing as separate activities, even if UIPE was doing the same.

ERB IN THE 4TH INDUSTRIAL REVOLUTION

As we went to press, we awaited proceedings of the December 2019 Forum, whose theme is "The role of engineers in the Fourth Industrial Revolution."

We hope the ERB@50 forum will throw light on the future, hopefully for a better ERB.

Recognizing the PAST ERB Board Members

For Professional Excellence

The first board was appointed in January 1970, and was chaired by the late Eng James Zikusooka. This year 2019, the board and the engineering fraternity mark the 50th Birthday.

Like any other institution, ERB's history has been shaped by the economic, social and political factors of the country. There were even some periods when there was no board appointed. There have been sixteen boards to date, the current board being the sixteenth. In honour of the gallant engineers who have served the engineering fraternity since the creation of ERB, the boards and their compositions, from 1970 to date, are given here-below (and for colleagues who have since passed on, may their souls rest in eternal peace.

1st ERB Board – January 1970 – March 1971	
Eng. J.M.N. Zikusooka	Chairman
Eng. A.P.N. Waligo	Vice-Chairman
Eng. Denis G. Kabega	Member
Eng. A.F. Luba	Member
Eng. A.S.N. Kiwana	Member
Eng. B.S. Knowles	Member
Eng. C. Harris	Member
Eng. J.S. Crisfield	Member
Eng. R.W. Dronyi	Registrar
Eng. G.N. Karugonjo	Registrar
Eng. G.N. Karugonjo	Secretary
Eng. G. Oworaga	Secretary
2nd ERB Board – April 1971 – September 1972	
Eng. G.N. Karugonjo	Chairman
Eng. G. Harris	Vice-Chairman
Eng. A.S.N. Kiwana	Member
Eng. J.S Crisfield	Member
Eng. Denis G. Kabega	Member
Eng. A.P.N. Waligo	Member
Eng. A.F. Luba	Member
Eng. G.W. Oworaga	Registrar
Eng. P.M.O. Onen	Secretary
3rd ERB Board – October 1973 – August 1976	
Eng. G.W. Oworaga	Chairman
Eng. A.P.N. Waligo	Member
Eng. C.A. Liburd	Member
Eng. H. Nalika	Member
Eng. M. Oyo	Member
Eng. P.M.O. Onen	Member
Eng. W. Kyobe	Member
Eng. P. Ssebowa	Registrar
4th ERB Board – September 1977 – February 1979	
Eng. R.W. Dronyi	Chairman
Eng. A.P.N. Waligo	Member
Eng. C.A. Liburd	Member
Eng. W. Kyobe	Member
Eng. M. Oyo	Member
Eng. A.W. Kapere	Member
Eng. J.M.H. Katende	Member
Eng. P. Ssebowa	Registrar
5th ERB Board - November 1979 – July 1980	
Eng. W. Kyobe	Chairman
Eng. A.W. Kapere	Member
Eng. M. Oyo	Member
Eng. J.M. Katende	Member
Eng. S. Onzoma	Member
Eng. Member	Member
Eng. Member	Member
Eng. P. Ssebowa	Registrar
6th ERB - Board August 1980 – February 1982	
Eng. W. Kyobe	Chairman
Eng. A.W Kapere	Member
Eng. M. Oyo	Member
Eng. J.M. Katende	Member
Eng. S. Onzoma	Member
7th ERB Board - August 1983 – May 1985	
Eng. G.W. Owaraga	Chairman
Eng. A.F. Luba	Member
Eng. E.A. Oryang	Member
Eng. M.W. Wambwa	Member
Eng. D.W. Nsubuga	Member
Eng. G.N. Karugonjo	Member

Eng. F.P. Openyto	Member
Eng. A.W. Kapere	Member
Eng. J.A. Byaleero	Registrar

8th ERB Board - 1987 – 1990

Eng. J.M. Kabwama	Chairman
Eng. Dr. S.E. Kiggundu	Member
Eng. E.K. Bagarukayo	Member
Eng. Dr. S.P. Kagoda	Member
Eng. G.W. Nyanzi	Member
Eng. Y.B. Mpagi	Member
Eng. A.E. Oryang	Member
Eng. J. Kawanaku	Registrar
Eng. Dr. A.M.S. Katahoire	Secretary

9th ERB Board - 1991 – 1992

Eng. G. Musoke	Chairman
Eng. H.R. Kibuuka	Member
Eng. Dr. A.M.S Katahoire	Member
Eng. Dr. J.K.D Higenyi	Member
Eng. S.G. D'Ujanga	Member
Eng. Odur-Okello	Member
Eng. S.P. Kagoda	Member
Eng. J.B. Mutabazi	Registrar

10th ERB Board - 1993 – 1998

Eng. H.R. Kibuuka	Chairman
Eng. Henry I. Kaliisa	Member
Eng. Hilary Kakeeto	Member
Eng. Dr. J.K.D. Higenyi	Member
Eng. F.F. Tusubira	Member
Eng. J.B. Walusimbi	Member
Eng. V.Z. Gashaija	Member
Eng. J.B. Mutabazi	Registrar

11th ERB Board – April 1998 – 2000

Eng. V.Z. Gashaija	Chairman
Eng. Dr. B.M. Kiggundu	Member
Eng. Dr. F.B. Ssebowa	Member
Eng. Dr. V.B.A. Kasangaki	Member
Eng. C.H. Azuba	Member
Eng. J.B. Walusimbi	Member
Eng. P.M. Njuki	Member
Eng. J.B. Mutabazi	Registrar

12th ERB Board – April 2000 – 2006

Eng. Dr. Charles Wana-Etyem	Chairman
Eng. Dr. Joseph Byaruhanga	Member
Eng. Sottie Bomukama	Member
Eng. Ssebbuga-Kimeze	Member
Eng. Paul Mubiru	Member
Eng. Hans J.W.B. Mwesigwa	Member
Eng. Sebide Sentongo	Member
Eng. James Okiror	Registrar

13th ERB Board – 1st May 2007 – 31st April 2009

Prof. Jackson A. Mwakali	Chairman
Eng. Livingstone S. Kangere	Member
Eng. Dr. Moses K. Musaazi	Member
Eng. Paul Mubiru	Member
Eng. Masitula Munyaami Male	Member
Eng. Stephen O. Kinyera	Member
Eng. Dominic Kavutse	Member
Eng. James Okiror	Registrar

14th ERB Board – 1st April 2011 – 31st March 2013

Prof. Jackson A. Mwakali	Chairman
Eng. Livingstone S. Kangere	Vice- Chairman
Eng. Joseph Oriono Eyatu	Member
Eng. Paul Mubiru	Member
Eng. Masitula Munyaami Male	Member
Eng. Dr. Moses K. Musaazi	Member
Eng. Stephen O. Kinyera	Member
Eng. James Okiror	Registrar

15th ERB Board – February 2014 – 31st January 2016

Eng. Dr. Michael M. Odongo	Chairman
Eng. Livingstone S. Kangere	Vice- Chairman
Eng. Joseph Oriono Eyatu	Member
Eng. Andrew M. Kitaka	Member
Eng. Dr. Anthony G. Kerali	Member
Eng. Bernard Kisembo Amooti	Member
Eng. Masitula Munyaami Male	Member
Eng. Peter Balimunsi	Member (co-opted)
Eng. Dr. Harrison Mutikanga	Member (co-opted)
Eng. George Bwanga	Registrar

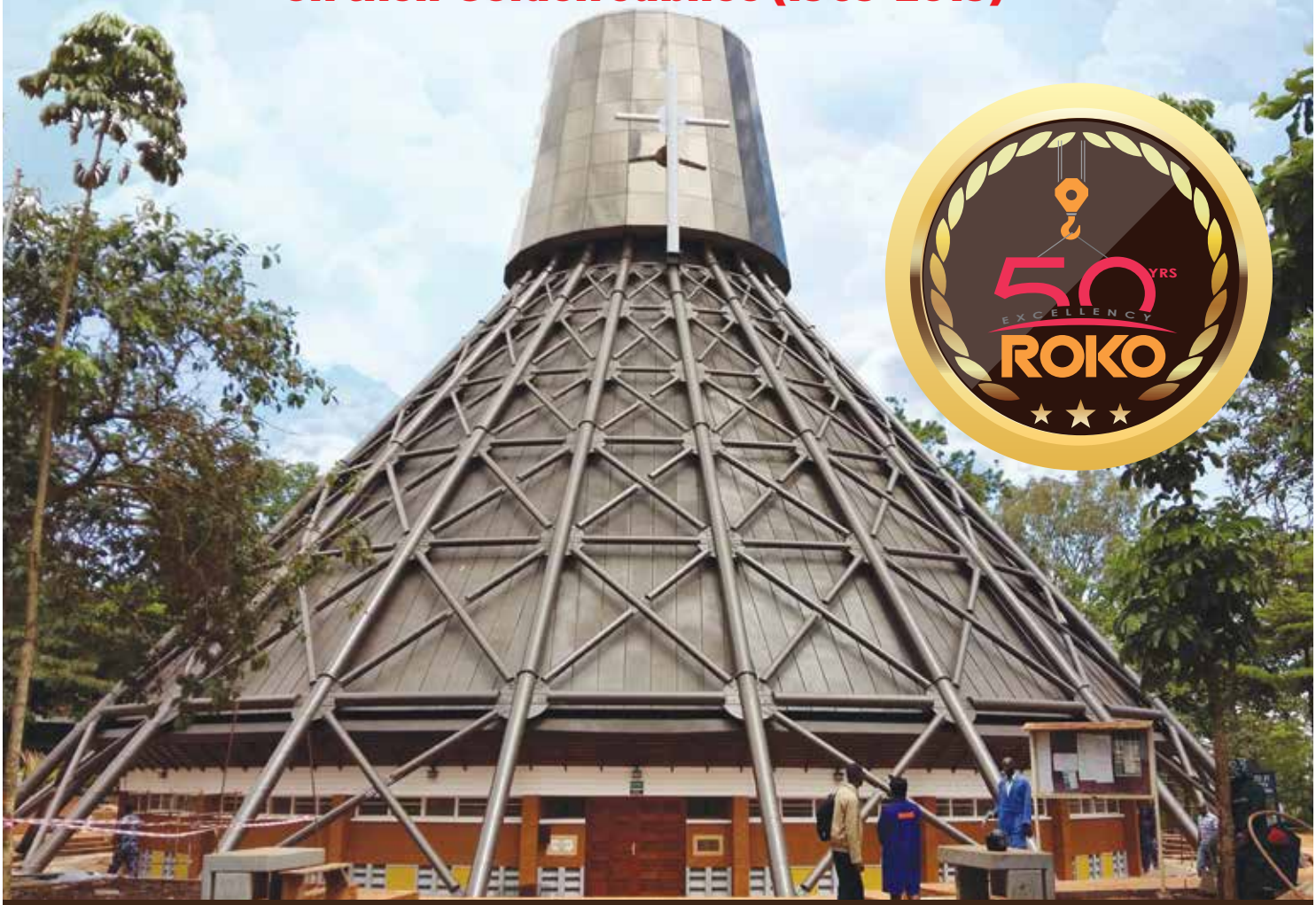
16th ERB Board – 1st Feb. 2016 – 31st Jan. 2018

Eng. Dr. Michael M. Odongo	Chairman
Eng. Kisembo Bernard Amooti	Vice-Chairman
Eng. Joseph Oriono Eyatu	Member
Eng. Andrew M. Kitaka	Member
Eng. Henry Francis Okinyal	Member
Eng. George Bwanga	Member
Eng. Dorothy Okello Kabagaju	Member
Eng. Peter Balimunsi	Member (co-opted)
Eng. Dr. Harrison Mutikanga	Member (co-opted)
Eng. Ronald Namugera	Registrar

ROKO CONSTRUCTION LTD. SINCE 1969

ISO 9001:2015
BUREAU VERITAS Certification

The Board, Management and Staff of ROKO Construction Ltd congratulate the Engineers Registration Board on their Golden Jubilee (1969-2019)



OUR SERVICES

- **Turnkey Projects**
- **Ready Mix Concrete**
- **Carpentry and Joinery Works**
- **Aluminium Fabrication Works**
- **Electrical and Plumbing**
- **Pre-cast Concrete Products**

Uganda Martyrs Shrine at Namugongo was our first **major Job** in Uganda after ROKO's incorporation in 1969.
Since then we have evolved to be a **self-sufficient** principal contractor in Uganda

Contact Us

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Eng. Dr. Michael M. Odongo/**Chairman**

A 54-year-old civil engineer with 30 years' professional practice in development, management/ maintenance/ financing of transportation infrastructure, mainly roads and bridges. Has 10 years' experience in corporate leadership as pioneer Executive Director of Uganda Road Fund (1.11.2009 to 31.10.2019). As pioneer ED of the Road fund, had the rare experience of starting a commercially oriented public enterprise from scratch and nurturing it to maturity over a decade within a very challenging and dynamic policy environment. For the past 6 years from 2014 to-date is Chairman of Engineers' Registration Board. For 3 years from 2015 to 2018 was Chairman Board of Trustees of the Uganda National Cultural Centre. Held several senior positions of responsibility within the Civil Service of Uganda including being Chief Materials Engineer from 2007 to 2009. Been coordinator/ team-leader on several multi-million dollar donor-funded road/bridge projects. Holds advanced degrees in engineering and management, has researched, published and briefly taught engineering at Makerere University. An excellent communicator, networker and community mobilizer, he has a track record of achievements in the road industry in Uganda and East African.

Eng Henry Francis Okinyal/**Vice Chairman**

Holds BSc in Engineering from Makerere University and MSc (Agricultural Engineering) from University of Melbourne, Australia. He is a UIPE member (No. PE 314) and a registered engineer (No. 395). He has an illustrious, uninterrupted formal employment record as a mechanical engineer (Design & Development) from 1977 to 1992, principal of Busitema National College of Agricultural Mechanisation (1992 - 2000), assistant commissioner for Technical Education in the Ministry of Education and Sports (2000 - 2001), and then received accelerated promotion to Commissioner for BTVET (2001 - 2010). He was the first substantive Director of the Industrial Training (DIT) until he retired from service in 2014.

Eng. Michael M. Pande/ **Member**

With over eighteen years' working experience in the engineering and infrastructure field, Eng. Pande Michael has worked in several key positions on a multitude of projects for government and private sector and has acquired expertise in: Programme development and management; Project development and project management; General management and contract administration; Adjudication; Staff coaching, mentoring and team building; Physical infrastructure feasibility studies and investigations; Design, costing and construction supervision of engineering structures; Physical infrastructure assessments; Structural integrity appraisals of engineering structures; Geotechnical and Materials studies and Laboratory testing of materials; Bid and Tender Evaluations for infrastructural works; Technical and Value for Money Audits; Infrastructure equipment evaluations; Industrial Processes audits; Institutional procedures reviews; Ministry of Education Needs Assessments for Secondary Schools and Tertiary institutions; and Preparation and management of National and International Professional Events. He has previously served as Vice President (civil division) of the Uganda Institution of Professional Engineers (UIPE) and as Vice Chairman of the Uganda Association of Consulting Engineers (UACE).

Eng Andrew M. Kitaka/**Member**

Kitaka is a registered engineer with the Engineer's Registration Board of Uganda and is a member of the Uganda Institution of Professional Engineers. He holds a Bachelor of Science in Civil Engineering from Makerere University and a Master's degree in Road and Transportation Engineering from IHE/ Delft University in the Netherlands. Kitaka, who boasts of 19 years' working experience, has attended specialized training courses in urban transportation planning and reform in Japan and Ghana, and was on the government delegation to Bogota, Colombia in 2008 to study the state of the art rapid bus transit system for possible implementation in greater Kampala in a bid to alleviate traffic congestion in the city. He began his engineering career in the private sector with Kagga & Partners Consulting Engineers from where he joined the public sector in the Ministry of Works and Transport before joining the Uganda National Roads Authority. Prior to his appointment as KCCA director, Kitaka was working with the European Union as an operations officer in charge of roads infrastructure. He is the current Acting Executive Director of KCCA.

Eng Elias Bahanda/ **Member**

He is a registered electrical engineer with over three decades of uninterrupted working experience in engineering planning, project management, operations and maintenance. He has worked at different technical and managerial levels in the telecommunications sector in Uganda in addition to project management and coordination based at the East African Community (EAC) headquarters in Arusha. His experience in the provision of consultancy services in the EAC region is diverse including, but not limited to, pre-feasibility studies for National Backbones for Kenya, Uganda, Tanzania, Rwanda and Burundi; National Fibre Optic Backbones for Rwanda and Burundi; assessment of the transit market in Tanzania for Malawi submarine cable Virtual Landing Point (VLP); broadband connectivity for the EAC region, and feasibility studies for the Maritime Communication System on Lake Victoria. He is to date an ICT consulting engineer.

Eng Dr Florence Lubwama Kiyimba/**Member**

A registered agricultural engineer employed by the National Agricultural Research Organization (NARO) as a senior research officer. Florence brings wealth of experience of over 19 years in carrying out demand-driven research in designing, fabricating, testing/evaluation and disseminating appropriate technologies. She has comprehensive knowledge and understanding of agricultural process engineering systems for smallholder, medium and large-scale farmers. She has served in various leadership roles including: head of the Agricultural Engineering and Appropriate Research Centre; programme leader for the Biosystems and Agricultural Engineering Programme and head of several agro-processing projects.

Eng Peter Balimunsi/**Member**

An engineer, with training, experience, and interest in socio-economic development. Eng Balimunsi is an electrical engineer with extensive experience in management of engineering projects, general management of organisations and institutions, maintenance management, performance improvement programmes, institutional development, investment planning and management, multi-donor programme coordination, stakeholder management, and teaching. he worked as a Project Manager in National Water and Sewerage Corporation. He is the current commissioner for industry at the Ministry of Trade, Industry and Cooperatives.

Eng Ronald Namugera/**Registrar**

Eng Ronald Namugera is the registrar of the Engineers Registration Board (ERB) effective 1st February 2016. He is a registered civil engineer with experience in roads, bridges and geotechnical engineering fields. He has also acquired experience in public road infrastructure services procurement, road maintenance management and financing. He works at the Uganda Road Fund as Manager for Policy & Strategy

Eng Bernard Kisembo Amooti/**Co-opted Member**

Eng Kisembo Bernard Amooti, is an electrical engineer by profession, and holds a Bachelor of Science (Electrical) degree from Makerere University. He is a registered engineer with the Engineers Registration Board (and a former vice chairman). He is a Co-opted Member of ERB, and a member of the ERB Electrical Panel, as well as ERB/UIPE Joint Assessment Committee (JAC). He works with Multi-Konsults Ltd, as project manager (Electrical), for over 20 years, where he offers engineering consulting services in the electrical-mechanical disciplines and related fields. Eng Kisembo has an all round vast practical experience in the electrical engineering field through his work in the manufacturing sector, construction industry and various engineering consultancies. He has undertaken feasibility studies, designs and construction supervision of various major projects in the building industry and infrastructure projects, including water works, power distribution networks and medium and high voltage sub-stations, amongst others.

Eng George William Bwanga/**Co-opted Member**

He holds a Bachelor of Science in Civil Engineering from Makerere University and a Master of Science in Construction from Loughborough University. He is a member of the Uganda Institution of Professional Engineers, a registered engineer with the Engineers Registration Board and an Associate member of the Chartered Institute of Building (UK). He was the registrar of the 15th ERB, and has been board member of the 16th ERB and has now been co-opted in the 17th ERB. During the same period he served on the Joint Assessment Committee, chaired the Technical Committee (16th ERB), chaired the Editorial Board (17th ERB) and is a member of the Women Engineers, Technologists and Technicians (WETT) Committee. He has worked with the Ministry of Local Government, lectured at the Uganda Polytechnic Kyambogo, worked with the Ministry of Works and Transport, the Road Agency Formation Unit and the Uganda National Roads Authority. He is currently the manager infrastructure, industry and physical planning at the National Planning Authority.

ERB SECRETARIAT

Ms. Jacquelyn Kia
Administrator

Ms. Irene Nambuya
Accounts Officer

Ms. Natukunda Bertha
Registration Officer

Mr. Henry Onen
Logistics Assistant

Ms. Florence Namakula
Office Attendant

THE AWARD-WINNING RUBAGABAGA HYDROPOWER PLANT

by Abraham Dawit CEO, NEWPLAN CEO

Rubagabaga Hydropower Plant is a mini hydropower plant on the Rubagabaga river in Nyabihu and Ngororero districts in Rwanda that will generate 450KW of electricity. It was built under the partnership between East African Power (EAP) and Energy Utility Corporation Limited (EUCL - Rwanda) to contribute power to the national grid. The aim of this hydropower project was to launch a private-public community partnership with local businesses, to produce clean electricity, and to boost the socio-economic activities in the region.

Rubagabaga Hydropower Plant was the first hydropower project to implement a containerized turbine and generator in East Africa. This project was very unique because the plant was built almost entirely using simple manpower with little mechanical intervention and the project therefore gives credit to the innovative and resourceful nature of the Rwandan people. For example, problems of access to the construction site on a steep hillside across a ravine made it extremely difficult for on-site teams to transport each section of pipe from the offloading area to its respective position. The developer solved this problem by inventing a zip-line pulley system anchored to each side of the ravine, rigging each pipe to the wire, and pulling it across to the other side. This innovation saved a great deal of time and energy in the pipe assembly process. Being in such a remote location brought about many logistical challenges and lack of access caused 90% of the project to be built completely through manual labour. In addition to the 450kW delivered to the national grid, Rubagabaga has created more than 1000 jobs over the span of its life thus far.

THE CONSULTANTS & CONTRACTORS

Following a competitive bidding procedure NEWPLAN Limited was appointed by East African Power (EAP) for supervision of the construction works and commissioning of Rubagabaga Mini Hydro Power Plant.

Rubagabaga Hydropower Limited was the main contractor of the project. Haneseth Gruppen AS, GEMT Company LTD, DASSY Engineering

2 Rubagabaga won the 2018/2019 best small-scale renewable energy project <5MW in the African Energy and Industry Awards in Cape Town.

Solution, and EHB-Hydroelectric Limited are sub-contractors for Electromechanical services, access roads and bridges, penstock installation, and MV transmission lines respectively. Detailed design of the project was controlled by KGM engineering Africa. NEWPLAN Ltd supervised construction and commissioning of the power plant.

PROJECT PARTICULARS

Intake Weir

The Rubagabaga intake weir is 9m high and 33m long on crest. All appurtenant hydraulic structures of RHPP is imbedded on body of the intake weir. Rubagabaga intake weir consists of one flushing outlet (1mx1m), one low level outlet (1mx1m), one intake gate (1.4mx1.4m), 1m wide walkway on top of the weir and, uncontrolled 9m long spillway.

Headrace canal

The water directed from the river through intake is conveyed through the headrace canal up to the desander. The as-built dimension of Rubagabaga headrace canal is 1000m in length, 0.8m in width, and 1m in depth with a longitudinal slope of 1:1000. It has a design capacity of 1m3/s. Rubagabaga headrace sill level at the canal's starting point is 1473.8 masl, ending up at around 1472.55masl near the desander.

Desander

Rubagabaga hydropower project consists of one desander chamber. It has a single basin designed to trap 0.2 mm particles and equipped with an automatic flushing system of the sediments. The desander is 25m long, 5m wide and an overall depth of 3.7metres. Rubagabaga desander inlet and outlet basin floor level elevations are 1472.55 and 1469.854masl respectively.

Head tank/forebay

In order to make the transition between the desander and the low-pressure pipe, the forebay was proposed. Rubagabaga hydropower project forebay is 2m long, 5m wide, and 3.7 m deep.

Low pressure pipe

Rubagabaga hydropower low pressure pipe is a 418.24m steel pipe. It consists of two different outer diameter (OD) 820/6mm and 760/6mm.

Penstock

Rubagabaga hydropower penstock is 161.6m long steel pipe with an outer diameter (OD) of 630/8mm.

Powerhouse and Tailrace

Rubagabaga hydropower powerhouse is a surface type structure of still container and fixed on concrete foundation and located on the right bank of river. The powerhouse accommodates one Francis turbine-generator, and separate control block and offices.

Transmission Line

Rubagabaga hydropower project consists of about 2Km MV Transmission Line.

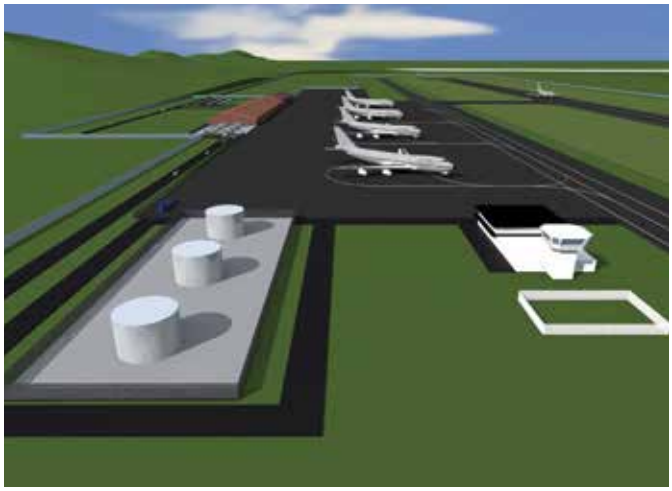
Access Road

Reliable access to the project site is required to be available under all weather conditions for efficient and timely construction and subsequent operation and maintenance of the hydropower plant. Rubagabaga hydropower project consists of about 200m gravel access road with a 4m wide and 10m long bridge.

3RUBAGABAGA Team of Engineers

OTHER NEWPLAN LTD PROJECTS

4 NKENDA Substation- Fort Portal



5 KABAALE International Airport (HOIMA) Masterplan

8 Hydropower Plant - Kasese

6 NEWPLAN MEDICARE - Ambulance Services

7 NEWPLAN surveyors working on the East African Crude Oil Pipeline (EACOP)

MAKERERE UNIVERSITY

CEDAT

The College of Engineering, Design, Art & Technology

About CEDAT

The College of Engineering, Design, Art and Technology (CEDAT) is one of the nine colleges of Makerere University and one school that makes up the academic units at Makerere University. The creation of CEDAT was a result of the major reforms in Makerere University's governance, financial and administrative structures, as well as academic programmes. The decision to transform Makerere University into a collegiate university was reached by Makerere University Council on 17th December 2010 following an earlier recommendation by the Senate meeting held on 4th November 2010.

CEDAT is comprised of three Schools and each of these has three academic departments: the Margaret Trowell School of Industrial and Fine Arts (MTSIFA) with the following departments: the Department of Fine Art, the Department of Industrial Art & Applied Design and the Department of Visual Communication, Design and Multimedia; the School of Engineering (SOE) has the Department of Civil and Environmental Engineering, the Department of Electrical & Computer Engineering and the Department of Mechanical Engineering; and School of the Built Environment (SBE) has the Department of Architecture and Physical Planning, the Department of Construction Economics and Management, and the Department of Geomatics and Land Management. CEDAT also has an institute of Heritage Conservation and Restoration and five centres which are the base for service and knowledge-transfer partnerships: Centre for Research in Energy and Energy Conservation (CREEC), the Centre for Research in Transportation Technologies, the Centre for Technology Design and Development, and the Centre for Geographical Information Systems (GIS) and the East African Centre for Renewable Energy & Efficiency

CEDAT mission is to undertake high quality research relevant to the region's and global development needs and consequently produce highly qualified graduates with specialized skills but equipped with holistic knowledge, as well as professional services and innovation for sustainable national and regional development.

Makerere University's vision is to be the leading institution for academic excellence and innovations in Africa and CEDAT identifies with this vision.

College Programmes

Undergraduate Programmes

Programme Name	Duration
Bachelor of Architecture	5 years
Bachelor of Industrial and Fine Arts	3 years
Bachelor of Science in Civil Engineering	4 years
Bachelor of Science in Computer Engineering	4 years
Bachelor of Science in Construction Management	3 years
Bachelor of Science in Electrical Engineering	4 years
Bachelor of Science in Land Economics	4 years
Bachelor of Science in Mechanical Engineering	4 years
Bachelor of Science in Quantity Surveying	4 years
Bachelor of Science in Land Surveying and Geomatics	4 years
Bachelor of Science in Telecommunication Engineering	4 years

Graduate Programmes

Programme Name	Duration
Doctor of Philosophy	4 years
Master of Science in Civil Engineering	2 years
Master of Science in Electrical Engineering	2 years
Master of Science in Mechanical Engineering	2 years
Master of Science in Renewable Energy	2 years
Master of Urban Planning and Design	2 years
Postgraduate Diploma in Urban Planning and Design	1 year
Master of Architecture	2 years
Masters of Arts in Fine Art	2 years
Master of Science in Technology Innovation and Industrial Development	2 years
Postgraduate Diploma in Construction Project Management	1 year
Master of Science in Construction Management	2 years
Master of Science in Geo-information Science and Technology	2 years
Master of Science in Power Systems Engineering	2 years
Master of Science in Telecommunication Engineering	2 years

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Feasibility of solar radiation to kill pathogens in water for domestic use

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Project Background

Many people in the world lack access to improved and safe water supply. Most rural communities use firewood as an energy source to disinfect water by boiling, leading to environmental degradation since the trees which help in rain formation are felled. Using sunlight can help such communities disinfect water on a small scale domestically with minimum effects on the environment. Water in plastic bottles is exposed to corrugated iron sheets for about six hours of direct sunlight. In sunlight, it is the UV light, particularly UV-A, which effects water disinfection in the whole electromagnetic spectrum by destroying the cells of pathogens; infrared radiation only raises the water temperature (Meierhofer & Wegelin, 2002). The drinkability of water is ascertained through carrying out the confirmatory tests i.e. bacteriological and physical.

Project scope

This research was limited to testing of water samples from shallow wells, boreholes, spring wells and Lake Kwania for turbidity and E.coli, respectively; and it was a case study of Lira District in formerly war-ravaged northern Uganda.

Project objective

To ascertain the feasibility of solar radiation to kill pathogens in water from all sources that would help developing countries have potable domestic water for healthy productive people as well as mitigate harmful carbon emissions to the environment which are the result of felling trees to boil the water for household use.

Project methodology

Water sampling

Sampling was done in accordance with the Guidelines for Drinking-water Quality in Annex 4 (WHO, 1997) using two sterilized sample bottle types (glass and PET) that were deemed free from contamination through proper handling and storage as shown in Figure 1.

Turbidity

Turbidity was done in accordance with the Guidelines for Drinking-water Quality in Annex 10 (WHO, 1997) using a turbidity tube to determine the organic and inorganic matter concentrations in the representative water samples as shown in Figure 2.

Figure 1: Water sampling from a borehole

Figure 2: Measuring turbidity using a turbidity tube

Escherichia coli (E.coli) concentrations

This test was done in accordance with the Guidelines for Drinking-water Quality in Annex 6 (WHO, 1997) to ascertain the E.coli colony concentrations before and after exposure of the representative water samples to direct sunlight for six hours using the sterile-membrane filtration technique as shown in Figure 3.

Figure 3: Placing a sterile-membrane filter on the apparatus

Result analysis

Turbidity

The turbidity of the different water sources was found to be less than five turbidity units (<5TU); and for groundwater sources (springs & boreholes). This may be due to the mechanical straining of undissolved suspended particles as the water percolates through the solid strata, meaning that the water is therefore undergoing filtration. As for surface water sources (Lake Kwania and shallow wells), this may be due to sedimentation because the suspended undissolved particles with mass densities greater than that of water move downwards and settle to the bottom. Shallow wells were also able to flush off lighter particles due to the steep slope of the land as shown in Table 1 and Figure 4.

Table 1: Turbidity of different water sources

	Turbidity (TU)								Mean	
Water sources	1		2		3		4			Standard deviation
Springs	5	5	5	5					5	0
Boreholes	5	5	5	5	5	5	5	5	5	0
Shallow wells	5	5	5	5	5	5			5	0
Lake Kwania	5	5							5	0

E.coli concentrations

(a) Before exposure to sunlight

All the water sources were found to be polluted with E.coli but Lake Kwania had the highest pollution levels and the boreholes the least. This is majorly due to the vast settlement of people within the vicinity who don't manage their domestic sewage properly since not all of them have pit latrines. This makes the surface water

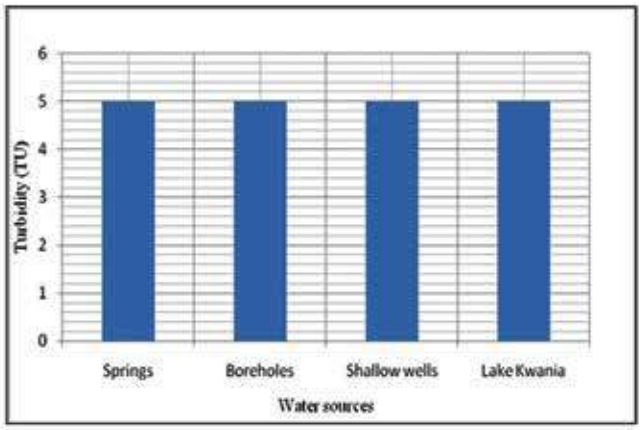

Figure 4: Turbidity of different water sources

runoff to wash the faecal matter into the lake; the boreholes were majorly polluted by pit latrines which were located uphill. The shallow wells were also found to be more polluted than the springs because of the pit latrines uphill, the animals that come to drink water and some of the people who bathe near the wells. (See Table 2 and Figure 5).

(b) After exposure to sunlight

All the water sources were found to be free from E.coli pollution. This is so because of a component of sunlight called UV radiations which interacts with the DNA, nucleic acid and enzymes of pathogens in addition to reacting with the dissolved oxygen in water forming high reactive-species (oxygen-free radicals & hydrogen peroxides) which changes their molecular structure and leads to cell death as shown in Table 3.

Conclusion

Basically this project was a success with three major highlights below:

- Turbidity of the different water sources was found to be less than 30NTU, which favours maximum penetration of the UV radiations into water without any interference to kill the pathogens.
- All the different water sources were found to have a varying degree of pollution by E.coli implying that people who consume water from these sources are likely to contract water-borne diseases.
- After SODIS, there were zero counts for E.coli meaning that the UV radiations from the sun have a lethal effect on pathogens present in water.

Recommendations

Demonstration projects should be carried out in order to attract public attention and encourage public participation. Therefore government agencies like National Water and Sewerage Corporation should be tasked with project monitoring and evaluation to determine the barriers and ways of overcoming them.

Table 2: E.coli of different water sources before exposure to sunlight

Water sources	E.coli (counts/100ml)								Mean	Standard deviation
	1		2		3		4			
Springs	30	32	74	76					53	25.4296415
Boreholes	8	6	0	0	20	22	0	0	7	9.196272537
Shallow wells	240	242	288	284	128	126			218	73.32121112
Lake Kwania	288	286							287	1.414213562

Table 3: E.coli of different water sources after exposure to sunlight

Water sources	E.coli (counts/100ml)								Mean	Standard deviation
	1		2		3		4			
Springs	0	0	0	0					0	0
Boreholes	0	0	0	0	0	0	0	0	0	0
Shallow wells	0	0	0	0	0	0			0	0
Lake Kwania	0	0							0	0

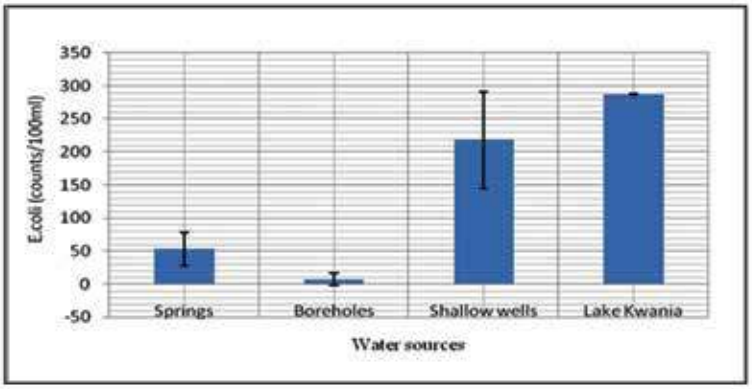

Figure 5: E.coli of different water sources before exposure to sunlight

For the effectiveness of this project to be realized, one should ensure that:

- The materials to be used are handled and stored properly.
- The turbidity of the water is less than 30NTU, and if it isn't, the water needs to be pre-treated by either decanting or filtration using a sand layer or a clean piece of cloth.

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Reinforcement of roads in soft soils using Geocells and Geogrids

Several areas in the Albertine region are compromised of generally poor in situ subgrade which are continuously characterized by soils of low CBR for approximately having a topography consisting of mainly flood plains. The conventional construction approach to similar sections in the past have also shown early failure as observed at Kabale – Katuna road (1997), Kabale - Hamurwa road and Kabale – Kisoro road (2013) mainly attributed to the weak subgrade. The Hoima–Kaiso-Tonya road (2014) has recently shown early subgrade failures and movements in areas where embankments were constructed over weak subgrade. These sections require incorporation of a stiff layer to take up the tensile stresses generated in the embankment like geocells and geogrids.

Geocells are three-dimensional honey-comb structures that use the cellular confinement technology to improve stress distribution of axle loads born on the road pavement to the under lying layers. Through this mechanism the subgrade is protected from high stresses yielding from the acting loads above the pavement. PRS Geocells and geogrids have been used in several countries to provide subgrade improvement and basal reinforcement. These geocells have been widely regarded as the recommended geocell due to its high stiffness factor and minimal deformation under constant stresses to remain durable and serviceable within the pavement structure. This is majorly attributed to the Neoloy alloy material composed within the cell walls which has a very low creep with high stiffness.

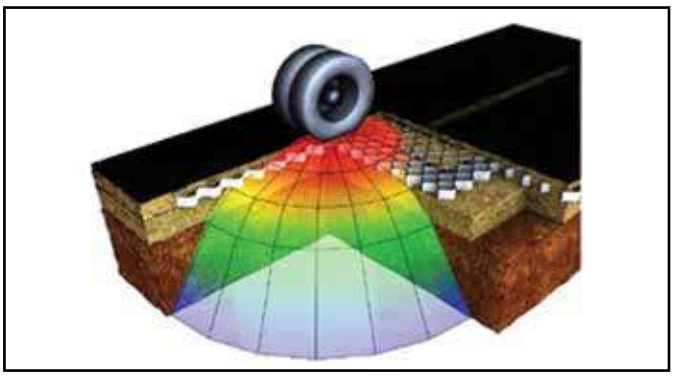
Admir Uganda Ltd is a local company established with the main objective of providing engineering support to the construction industry through supply of these geosynthetic materials, providing engineered designs and site support to ongoing projects. Dynaco Ltd also a local subsidiary of Admir Technologies from Israel provides the installation support and labour for these geosynthetic materials.

This technology of cellular confinement is mainly recommended due to the cost savings from reduction in the amount of rockfill and faster construction, utilization of the local inferior fill material within the geocells, improvement of the native subgrade modulus by an estimated factor of seven (07), improved pavement durability thus lower maintenance cycles and minimizes differential settlement due to the stiffer layer of the geocells acting in unison.

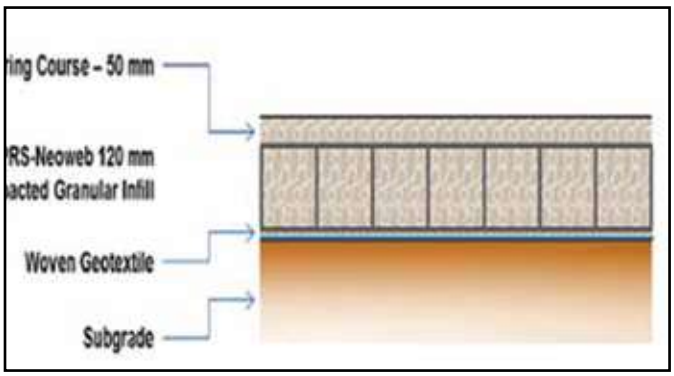
The Neoloy geocell provides up to 80% less rutting, 70% granular thickness savings and enables use of inferior graded materials. Due to the high modulus support for asphalt to reduce tensile strains in the layer, the geocells can provide 35% asphalt savings and base or sub base thickness savings.

Research has indicated that the Neoweb geocells create a beam effect within the pavement through a semi-rigid platform built up from the confinement of unbound granular material which eventually increase the strength of infill soil by up to 300% and more with an effective reduction of vertical stress to the lower layers.

Illustration of the procedures of Geocell Installation



Beam Effect



Layer of geocells prepared

Infill of materials into the Geocells

Layer of geocells prepared

Geogrid installation during the reconstruction of the Kibimba swamp crossing

Tying geogrid overlaps at subgrade

rolling geotextile and geogrids to Form filter

Stone filter before backfilling

Road section today

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Kyambogo University's Faculty of Engineering is the largest Engineering Faculty in Uganda in terms of student population and infrastructure. Engineering training at Kyambogo University started in 1928 as Kampala Technical School (KTS) on Makerere Hill which moved to Nakawa in 1942 and was relocated to Kyambogo Hill in 1954 where it was renamed Kampala Technical Institute, then later transformed to Uganda Technical College (UTC) in 1964 and upgraded to Uganda Polytechnic Kyambogo (UPK) in 1986. UPK eventually became the current Faculty of Engineering when Kyambogo University (KYU) was established in 2003 by the Universities and Other Tertiary Institutions Act 2001 (Instruments of 2003) as a merger of the Uganda Polytechnic Kyambogo (UPK), the Institute of Teacher Education Kyambogo (ITEK), and the Uganda National Institute of Special Education (UNISE).

The Faculty of Engineering at Kyambogo University is engaged in high-quality engineering training and collaborative research in the areas of manufacturing engineering, automotive engineering, refrigeration and air conditioning, renewable energy, electrical and electronics engineering, biomedical engineering, water and sanitation engineering, building engineering, surveying, architecture, and building economics, among others.

The faculty offers graduate, undergraduate, and diploma study programmes in its four departments, namely: the Department of Mechanical and Production Engineering, Department of Electrical and Electronics Engineering, the Department of Civil and Building Engineering, and the Department of Lands and Architectural Studies.

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- MSc in Water and Sanitation Engineering
- MSc in Structural Engineering
- MSc in Construction Technology and Management
- Postgraduate Diploma in Advanced Manufacturing Systems Engineering

Undergraduate Study Programmes:

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- Bachelor of Engineering in Automotive and Power Engineering
- Bachelor of Industrial Engineering and Management
- Bachelor of Environmental Engineering and Management
- Bachelor of Engineering in Civil and Building Engineering
- Bachelor of Engineering in Electrical Engineering
- Bachelor of Engineering in Telecommunications
- Bachelor of Mechatronics and Biomedical Engineering
- Bachelor of Science in Building Economics
- Bachelor of Science in Land Economics
- Bachelor of Science in Surveying & Land Information Systems
- Bachelor of Architecture

Diploma Study Programmes:

- Higher Diploma in Mechanical Engineering
- Higher Diploma in Civil and Building Engineering
- Higher Diploma in Electrical Engineering
- Diploma in Refrigeration and Air Conditioning
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- Diploma in Mechanical Engineering
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No longer a silent temple but a learning commons

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Cynthia Mukyala is a recent graduate from Uganda Martyrs University Nkozi with a Bachelor's degree in Environmental Design (March 2018); a preparatory undergraduate training for a professional course in Built Environment such as architecture, landscape architecture, or urban planning. She has particular interest in the research and psychology of space, and wrote a dissertation on Libraries in the 21st century seeking to establish the spatial response of the library at UMU to learning in the 21st century. She believes that with the ubiquitous access to the Internet and the rapid advancement in technology, the role of libraries and learning spaces is changing and that to produce competent learners, learning institutes need to adapt to the changing roles of these spaces.

ABSTRACT:
The digitization of content and the evolving skills required in the corporate environment have changed learning and teaching styles and consequently the role of libraries and learning spaces in the 21st century. Learning theory now emphasises the creation of knowledge and self-direction in the transmission of knowledge. Interventions, therefore, have theorised a new concept for libraries—the *Learning Commons*—spaces that support the now social nature of learning and knowledge creation. Libraries around the world therefore are transforming from silent temples that hold collections and reference materials into multi-use spaces—hubs of creativity and market places for ideas. How well have the learning spaces and libraries in Uganda adapted to the new learning styles? This article is based on research that aimed at evaluating how well the Archbishop Kiwanuka Memorial Library at Uganda Martyrs University, Nkozi, has adapted to learning in the 21st century.

The ubiquity of the Internet and the digitization of content in the 21st century has changed the way students take in information and utilise learning spaces and libraries. Students no longer need libraries simply to access knowledge but rather to interact with peers, synthesize information, relate it to the real world and produce more information. Therefore, rather than maintain an atmosphere singularly for individual study, libraries need to create an environment for collaboration and knowledge co-construction. Libraries hence become less about storing books and more about connecting learners. In addition, the Fourth Industrial Revolution requires more interdisciplinary individuals with in-depth knowledge of a specific field, but with sufficient knowledge in other fields to complement and enrich their field of expertise. Education therefore is centred on facilitating collaboration, project-based learning, and peer-to-peer tutoring as a way of encouraging self-learning. Learning is no longer seen as primarily an individual pursuit but rather a social act carried out with ample use of technology.

Libraries and learning spaces therefore are evolving into social and cultural spheres—moving away from the idea of knowledge access to knowledge construction, from isolation to collaboration. A new concept for library spaces has consequently emerged—the *Learning Commons*.

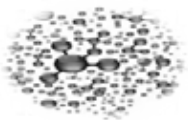
Learning commons reflect user roles as both knowledge consumers and producers by focusing on users' collaborative efforts to process information as well as the appropriate tools used such as open access publishing and copyright management. This implies that libraries now need both quiet and collaborative learning opportunities along with access to cutting-edge technology and refreshment. Libraries in the United States and around the world are in response transforming from silent temples that hold collections to hubs of creativity and market places for ideas.

The strength of the appeal of a learning commons can be explained by Lev Vygotsky, a Russian psychologist (1896-1934), who called a great deal of attention to the social nature of learning. Central to his theory is the "Zone of Proximal Development (ZPD)"—the area of exploration for which the student is cognitively prepared, but requires help and social interaction to fully develop. A teacher or more experienced peer is then able to provide the learner with "scaffolding" to support the student's evolving understanding of knowledge or development of complex skills. To maximize the ZPD, teachers need to set up social learning opportunities in which students can work with other students. Learning commons are designed to encourage and enhance the social contexts of learning where students can help each other clarify confusing concepts and where information needs can be addressed by consultation, discussion and problem-solving.

Flexibility is one of the vital qualities required to realise the Learning Commons models as a variety of interiors and workspaces, responsive to the different learning needs and styles that must be offered. Flexible spaces provide opportunities for spaces to evolve and adapt to various user needs as well as future new roles. Faber (2013) summarises the idea of learning commons by outlining the elements that can be adopted to build a successful learning commons (See *Figure below*).

Student Centred
Customisable to unique student needs

Flexible spaces
Supports individuals, small, and large groups

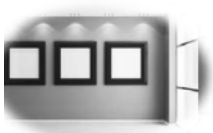


Connectivity
Virtual access connects with experts and ideas around the world

High Order Thinking
Activities, assessment and feedback support the development of this skills

Participatory Learning
Collaboration and the co-creation of knowledge

Collaboration
Establishing networks to support new ways of learning



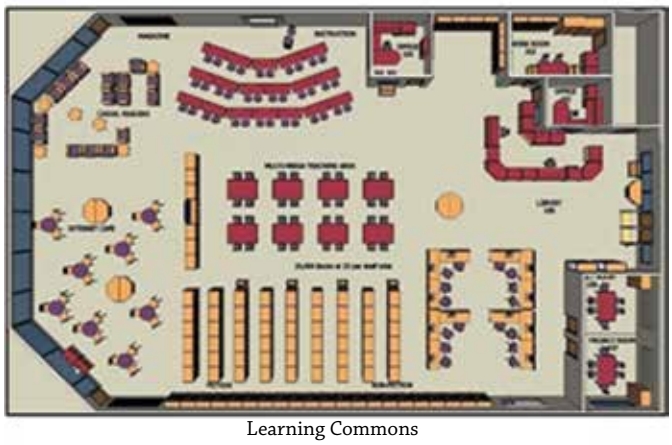
Showcased Learning
Physical and virtual displays demonstrating learning

Engagement
Social, intellectual and academic

Elements of a learning Commons (Faber 2013)

These qualities can be achieved by providing (1) open spaces that accommodate multi-use furniture that can be adjusted to meet a wide range of student needs, as opposed to heavy, immovable furniture; (2) a variety of designated areas—zones to serve the different learning user needs; and (3) interactive whiteboards for display of the output during discussions (See *Figure below*).

Individual Study | Small Groups | Large Groups



Learning Commons

Sullivan's Learning Commons Prototype-Spatial-layout

To sum it all up, libraries and learning spaces can be assessed using the criteria summarised in the Table below:

PRINCIPLES	AIM	SPATIAL QUALITY
	LEARNING STRATEGIES	
Student centred learning (Faber, 2013)	The library should put user needs first by allowing for **personalisation**	Adaptable to different individual needs
Engagement (Educause, 2011) (Faber, 2013) (Brisson, 2014)	The library should facilitate interplay of social interaction as well as quiet reading by providing for **social and intellectual interaction**	Zones for: • Working both in different sizes of groups and silence • Social interaction and refreshing- includes entertainment, relaxing furniture, and snacks
	SPACES	
Flexible spaces (Smith, 2015) (Building futures, 2004)	The library should be able to adapt to **future changes** and accommodate **large group** presentations, **smaller clusters** and **individual students** in need of a quiet space	• Multiuse, open spaces • Moveable furniture • Multi-use furniture
Stimulation (Matthews, 2011)	Library spaces should have a vibrant feel to **motivate students**	• Exposure to natural light • Display of artifacts • Colour
	TOOLS	
Show-cased learning (Faber, 2013) Technology (Faber, 2013) (Canada library association, 2014)	The library should provide **display tools (physical or virtual)** to support collaboration and serendipitous learning	• Display tools
	The library should have **technology integrated** to enable connectivity- connection with experts and ideas from around the world	• Access to power sources • Access to the internet • Tools- to publish constructed material such as videos, audios, podcasts, printed documents.

Summary learning commons spatial criteria

An example of a library that has successfully adapted to 21st century learning is the Brossard Public Library in Canada. It provides a variety of interiors catering for both silent and collaborative endeavours. They

include four zones: Working, Reading, Socialising, and Relaxing. Furnishings are easily moveable (light-weight, stackable, or with wheels) for reconfiguration and adaptation to changing needs.

The zone for working facilitates the students' output with two desktop computers—equipped with advanced software for photo retouching, graphic imaging and video-making, a printer, and a SMART board (See *Figure below*).

Working space

The zone for reading has a bistro feel with elevated tables and chairs. Graphic novels and magazines are stored within moveable shelving units and storage boxes (See *Figure below*)

Reading space

The zone for socializing, which facilitates social interactions, has moveable tiered seating, two televisions, and five of the most recent video game consoles, along with a wide selection of board games used during scheduled game nights. Finally, four oversized rolls of paper on which teens are encouraged to express themselves are mounted on the wall (See *Figure below*).

Socialising space

The zone for relaxing, which is meant for refreshment, features cushions such as footstools and booths. Groups of teenagers can listen to the same music under two sound domes by plugging in their phones. The music can be heard by only those under the domes, so as not to disturb others in the room (See *Figure below*).

Relaxing space

In a world where technology is evolving rapidly, the roles of human labour are constantly changing. With these changes, engineers are constantly working to generate new systems and ways of thinking. It is important therefore for the education system to produce adaptable and versatile individuals by facilitating new styles of teaching and learning. Backed with substantial learning theory, it is imperative that learning spaces and libraries adapt to the new learning styles as well. How well are engineering students in Uganda prepared for this ever-changing world? And, how well have our learning spaces adapted to the new learning styles?

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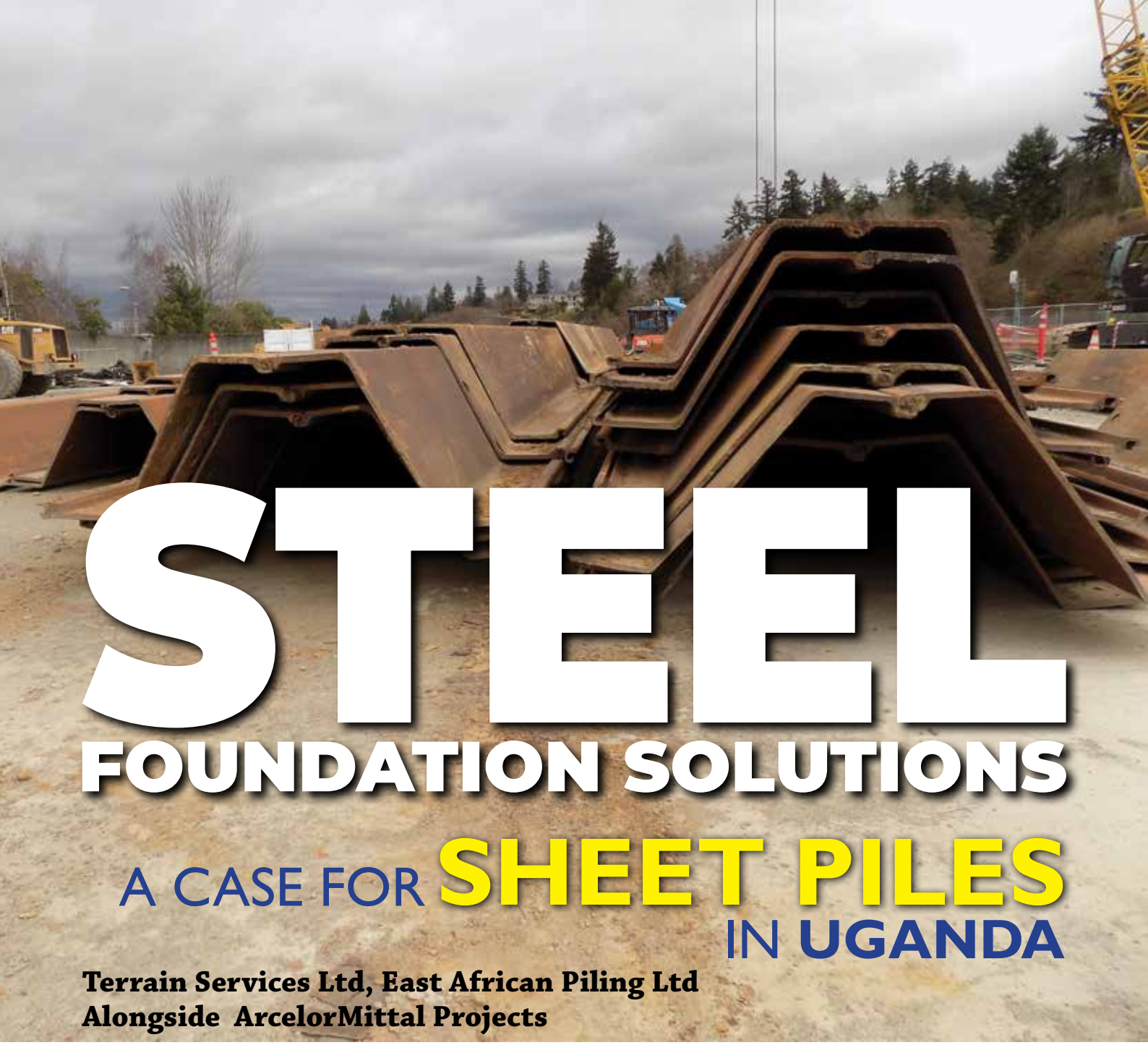

STEEL FOUNDATION SOLUTIONS

A CASE FOR SHEET PILES IN UGANDA

Terrain Services Ltd, East African Piling Ltd
Alongside ArcelorMittal Projects

Background

Steel sheet foundations have been used worldwide for the construction of quay walls, breakwaters in habours and embankment reinforcements on rivers and canals. They are also used on temporary cofferdams in land and in water, permanent bridge abutments, retaining walls for underpasses or underground car parks and impervious containment walls.

ArcelorMittal is the largest steel and mining company in the world and is also the world's leading manufacturer of hot rolled steel sheet piles. ArcelorMittal Projects can supply a complete solution package that can include accessories such as (anchoring material, walers, fabricated piles, driving caps), a full technical support from the conceptual design to the final installation process and additional features such as (special piles, coating, sealant material in the interlocks, etc)

In Uganda, Sheet piles can be used on high-rise buildings, especially those requiring underground parking. New offices and apartments need parking spaces, and due to space constraints, these parking areas might need to be located under the building to maximize on land usage. Underground car parks are a suitable solution for these new buildings, which are commonly constructed in densely populated urban areas, next to existing buildings.

To safely construct these car parks, it does not suffice anymore to simply excavate a building pit and commence building of the basement. Excavations cannot be left unsecured, particularly during the rainy season because of slope stability which requires to be supported by a retaining wall.

Retaining structures come in many forms and shapes. With the steel solutions provided by ArcelorMittal, risks are eliminated and building costs reduced significantly.

Sheet piles for bridge abutments

Sheet piles for underground parking

Sheet piles application at coastal areas

Availability in Uganda

Although safe steel sheet piles solutions have always been considered costly and not readily available in Uganda, ArcelorMittal Projects have established themselves in Uganda, through a partnership with Terrain Services Limited. Sheet piles are available for sale and rent, and can be installed by East African Piling Limited, a member of the Terrain Group of Companies. Technical, financial and practical knowledge are available in Kampala for your Piling requirements

The steel sheet piles solutions of ArcelorMittal Projects are a good investment as these solutions are not only complete, customised, safe and sustainable, but also generate additional revenues for the investors.

Added Value for Investors

With the top-down solutions, the execution time of the project can be reduced by 30% or more. Also, if the steel sheet piles solutions for retaining structures are used temporarily, these materials can be rented rather than purchased, which will allow for reduced project cost. In addition, ArcelorMittal also provides support with project plans, designs, logistics and all other facets of the retaining structure.

The partnership between ArcelorMittal and Terrain Services Ltd, also allows for the provision of the installation part of the project, hence offering a complete solution from initiation to execution.

The benefits of BIM in the construction industry

By Conrad Cyril Bwanga
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Conrad Cyril Bwanga is a recent graduate from Coventry University (UK) with a Master of Engineering (MEng) in Civil Engineering. He is particularly interested in researching about ways to address some of the challenges facing Uganda's construction industry such as delays of construction projects, cost overruns, miscommunication, health and safety issues, among others. He believes that smarter and more efficient ways of designing and building such as Building Information Modelling (BIM) should be adopted to tackle some of these challenges, meet the population and economic demands of Uganda and also create buildings and infrastructure that are smarter and more resilient.

ABSTRACT:

Infrastructure projects are becoming more and more complex by the day making project team collaboration and cost predictability critical aspects in the construction industry. With Building Information Modelling (BIM), these processes can all be made easy as it formulates and generates project-related data in a shared online space accessible to all project team members. There has therefore been an increasing demand for BIM within the architecture, engineering, and construction (AEC) industry internationally. It has been actively employed in most of the developed countries. However, it is yet to be picked up by most developing countries such as Uganda. If we took up BIM in Uganda, challenges such as cost overruns, delays, miscommunication, rework, and other related inefficiencies that affect project success would be minimised. This article elaborates the benefits of BIM application and how BIM can address some of the challenges of Uganda's construction industry.

INTRODUCTION

Building information modelling is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to plan, design, construct, and manage buildings and infrastructure more efficiently (Autodesk,2019). It involves creating information models out of graphical and non-graphical information in a shared online space known as a Common Data Environment (CDE).

Over the past few years, there have been many discussions about BIM in the construction industry. However, there are many misconceptions about BIM in construction and how it can help AEC professionals. One common misconception is that BIM is simply a technology, or that it only refers to 3D design. BIM is a process that starts with the creation of an intelligent 3D model and enables document management, coordination and simulation during the entire lifecycle of a project (plan, design, build, operation and maintenance) (Autodesk,2019). BIM is mostly associated with design and preconstruction. However, it benefits every phase of the project life-cycle, even after building is completed. BIM allows projects to be built virtually before they are constructed physically, eliminating many of the inefficiencies and problems that arise during the construction process (Designing Buildings Wiki, 2018).

One of the fundamental aspects of BIM is that it is a digital description of every aspect of the built asset. BIM involves information modelling and management in a team environment in which all team members work to the same standards as one another. Therefore BIM creates value from the combined efforts of people, processes and technology (Baden et al, 2017).

The Fourth Industrial Revolution represents an opportunity for the construction industry to evolve and set a new precedent for what is possible. BIM is the first step in this evolution by attempting to create a central repository to col-

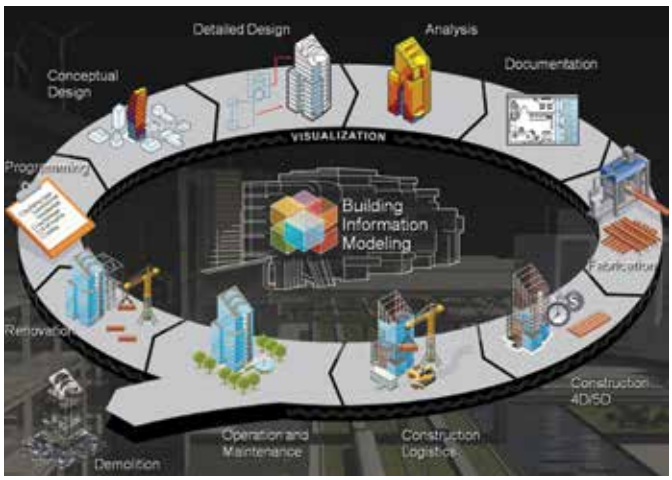

Fig 1: Building Information Modelling (Goubau, 2019)

late digital information about a project or asset (King, 2017).

BENEFITS OF BIM

Preconstruction project visualisation

BIM enables the planning and visualisation of the entire project during preconstruction before the actual construction takes place. Space-use simulations, virtual reality and 3D visualisations using BIM tools such as Autodesk's Revit allow clients to experience what the space

Fig 2: Preconstruction project visualisation (Anslow Byrant Construction Ltd, 2019)

will look like. This also enables them to make changes before construction starts (Hall, 2018)..

Better collaboration and communication

Digital BIM models allow for sharing and collaboration. These cannot easily be achieved with paper drawing sets. Using common data environments (CDE) such as Autodesk's BIM 360, collecting, managing and sharing information can easily be achieved among the team working on a project. The information includes the 3D models, non-graphical data, documentation and all other information relevant to the project (Mordue, 2015). Using CDEs is an effective tool in project management as it reduces the time and cost of producing coordinated information especially during the planning and design phase of a construction project.

Model-based cost estimation and improved scheduling

BIM can be used to develop accurate project programmes by linking the 3D-BIM system with time-scheduling data. This is known as **4D-BIM**. This data is added to components which will build in detail as the project progresses. This information enables planners to derive accurate programme information and visualise how the project will develop sequentially (NBS, 2019). The information may include how long it takes to install/construct, the sequence in which components should be installed and dependencies on other activities of the project.

BIM can be used to extract accurate cost information by linking the 3D-BIM model with cost-related information through the use of BIM tools of Autodesk's Revit and BIM 360 Docs. This is known as **5D-BIM.** Considerations might include the costs of purchasing and installing a component, its associated running costs and the cost of renewal (NBS, 2019). Calculations can be made based on the data and associated information linked to particular components within the graphical model. This information allows cost managers to easily anticipate the quantities of a given component on a project, applying rates to those quantities, thereby reaching the overall cost for the development (NBS, 2019).

Improved coordination and clash detection

BIM enables better coordination of trades and subcontractors, detecting any (mechanical, electrical and plumbing (MEP), internal, or external clashes, before construction begins. For instance, will the electrical conduits clash with a steel beam? Do the doorways have enough clearance? With BIM software such as Autodesk's BIM 360 Glue, clashes can be avoided with automated clash detection. This therefore reduces the amount of rework needed on any given job (Autodesk, 2019).

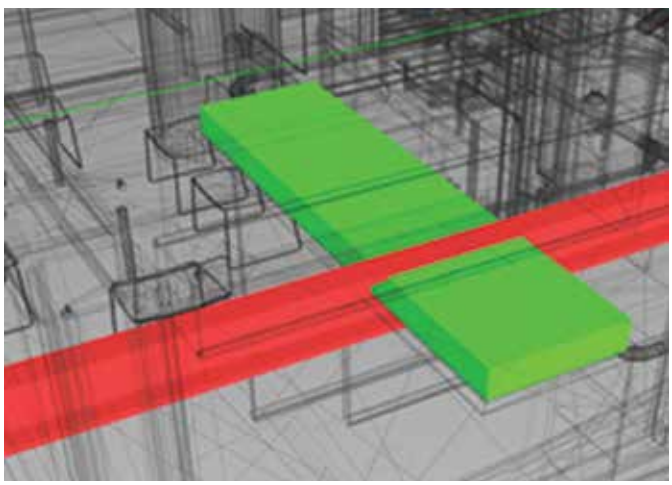

Fig 3: Clash detection (The BIM Centre, 2019)

Reduced cost and mitigated risk

Using BIM allows for closer collaboration between designers and contractors which leads to reductions in tender risk premiums, lower insurance costs, fewer overall variations, and fewer opportunities for claims (Autodesk, 2019). Moreover, a better overview of the project before starting allows for more prefabrication and use of modular construction technology. Building offsite in a controlled environment reduces waste of unused materials, increases efficiency, and reduces labour and material costs (Autodesk, 2019).

Health and safety

BIM helps in improving health and safety on construction sites by identifying hazards and physical risks before they become problems through visualising and planning site logistics before actual construction starts.

Stronger facility management and building handover

6D-BIM involves the inclusion of information to support facilities management and operation for the entire lifecycle of a development. This data might include information on the manufacturer of a component, the required maintenance and the details of how the item should be configured and operated for optimal performance, energy performance, along with lifespan and decommissioning data (NBS, 2019). Therefore, BIM is also an effective tool in the monitoring and evaluation of construction projects.

CONCLUSION

BIM is an effective risk management tool at the design, construction and operational phase of a project. It is a smarter and more efficient way to design and build to keep up with global demands and create spaces that are smarter and more resilient. This will help in the achievement of Sustainable Development Goal 9 – 'Industry, Innovation and Infrastructure' of the United Nations Development Programme (UNDP). The introduction of BIM as a new way of working in Uganda's construction industry will improve the efficiency, productivity, quality and sustainability of construction projects. It will also help to mitigate some of the risks/challenges such as delayed completion of projects and cost overruns through the use of BIM features such as 4D-BIM and 5D-BIM.

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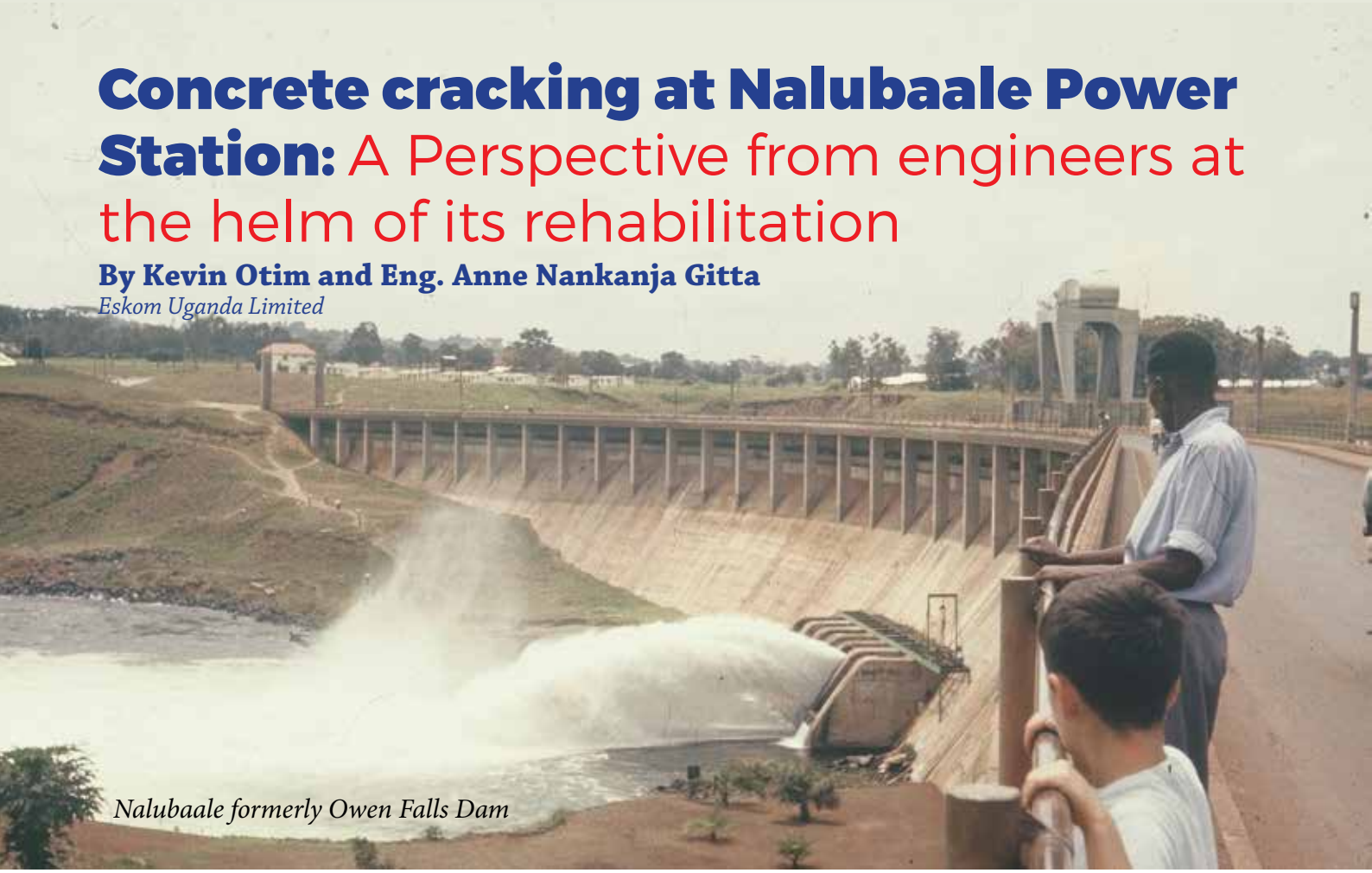
Concrete cracking at Nalubaale Power Station: A Perspective from engineers at the helm of its rehabilitation

By Kevin Otim and Eng. Anne Nankanja Gitta
Eskom Uganda Limited



Nalubaale formerly Owen Falls Dam

For the better half of Uganda's independence, the Nalubaale Hydroelectric Power Plant, formerly known as the Owen Falls Dam, has been at the core of power generation for the nation and export across its borders. Constructed across the great River Nile in 1954, just 3km downstream of the Lake Victoria, the station has stood the test of time despite the concrete cracking that has plagued the Powerhouse for the majority of its history. The nation has been awash with media stories about this cracking and questions linger in the minds of Ugandans regarding the 180MW power station's structural safety, its sustainability and its future role in the nation's energy sector.

Ten years after the construction of the Nalubaale Hydroelectric Power Plant, in 1964, cracking was first observed on the concrete of Unit 4, one of the 10 generating units installed at the station. The fact that the cracks were first observed during a year that coincided with a 2m rise in the water level of Lake Victoria, led to a suspicion that these cracks were caused by some form of structural distress due to increased water loading on the dam. Since the cracking was then limited to the concrete of generating Unit 4, no changes and interventions were implemented at that point.

During the 70's, the cracking in the powerhouse increased significantly with the cracks at generating Unit 4 being mirrored across the other 10 generating units and a 25mm longitudinal crack cutting across the station. There was quite a bit of political instability during that time in Uganda, hence the original designers of the station could not inspect the facility.

A number of rehabilitation efforts were attempted on the plant, such as stress anchoring of the concrete to alleviate the deterioration and stop the cracking. Eventually, petrographic analytical tests carried out in 1990, finally diagnosed the cracking as being due to a rare post construction oddity caused by Alkali Silicate Reaction (ASR), a chemical reaction between aggregate in the concrete with water that results into concrete expansion.

What is ASR in Concrete?

As you might be aware, concrete is a mixture of cement, aggregate and water. When the alkali hydroxide present in Portland cement reacts with certain siliceous rocks/aggregates such as chert, quartz and volcanic glass in the presence of water, it forms an alkali silica gel. This gel then continues to absorb water and expands exerting internal forces in the concrete, of up to 4-6Mpa causing the concrete to expand if unrestrained at rates between 20 – 150 micro-strains per year. This expansion leads to extensive cracking of the dry areas of the concrete that are unable to expand as a means to relieve stress. The result is often in the pattern of 'map-cracking' in the areas where concrete is unrestrained by adjacent structures or by internal reinforcement. The distinct map cracking, variable expansions and surface discolouration along

cracks are the more commonly reported external surface manifestations of ASR.

The subsequent issues that result from continued expansion include reduction in spillway and intake gate clearances, high shear stresses in concrete substructures, stressing and distortion of concrete around the turbine hub's steel lining and turbine/generator alignment problems.

At construction and early operational life of the Nalubaale HPP, all the conditions necessary for ASR were present and the Nalubaale Power Plant was bound to have concrete expansion related challenges. ASR was an unknown phenomenon at the time, and as such could not have even been foreseen. Most evidently at Nalubaale Power Station are the cracks along the machine hall and the turbine blocks caused by the ASR expansion and shown the figure 1.

Extensive research on ASR has been undertaken in

Figure 1: Crack at one of the turbine blocks in NPS

the recent decades with organizations such as The International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM), enabling the successful prevention of ASR through appropriate material testing before construction of concrete structures and development of guidelines for the diagnosis and appraisal of ASR damage to concrete. ASR in concrete can effectively be prevented by the use of a nonreactive aggregate, keeping the cement alkaline content below 3.0 kg/m3 and substituting supplementary cement with materials such as blast furnace slag, fly ash and silica fume which are non-reactive relative to normal cement.

There is however no known intervention method to decrease or permanently stop the expansive reactions within the concrete mass due to ASR once they have begun, hence the reason it has come to be known as a "concrete cancer". Methods such as injection of Lithium salts have been suggested in lab tests but are not feasible in large dams. Other methods such as waterproofing the up streams of dams, which easily comes at a cost of more than 5 million US dollars, have been tested but there is insufficient evidence to show if it's been able to reduce or stop the expansion. The rate of concrete growth in dams such as Nalubaale, has shown to be slowing down over time but the reaction is still expected to continue at a reducing rate for a substantial life of the structure.

To limit risk of further deterioration and failure of large ASR affected structures such as dams, the owners and operators have to resort to managing the movement by investigative studies, numerical modelling, monitoring continual movement and strengthening and remediating deteriorated areas. Such methodologies of management of ASR-related deterioration have been successfully applied and have shown positive life extension of a number of ASR-affected hydro-stations worldwide.

The future of Nalubaale operations

The manifestation of ASR on various hydropower structures tends to varry. Eskom Uganda Limited (EUL), the operator of the Nalubaale HPP have executed and are continuing to implement remedial solutions that are successfully managing the effects of the ASR expansion on the structure and associated embedded equipment, such as concrete cracking, misalignment of turbine embedded parts, and structural movement.

To extend the life of the Nalubaale HPP, strategies including modified approaches to maintenances, mechanical adjusting of machinery, structural modifications and concrete repairs on both the surface and subsurface have been applied (Figure 2). EUL has worked with various independent experts carrying out detailed investigative studies and numerical modelling efforts, to clarify the site specific expansion mechanisms, forecast future expansion as well as the potential and estimated benefits of structural remedial actions on the power house. Structural modifications such as strengthening the tailrace underwater columns by installation of an exo-support reinforcing structure and supporting the gallery access stairwells through affixing adjustable beam supports with ability to accommodate future movement are being pursued in the short term (Figure 3).

On recommendation from the Ministry of Energy and Mineral Development, and with the support from the Asset Owner UEGCL and the Electricity Regulatory Au-

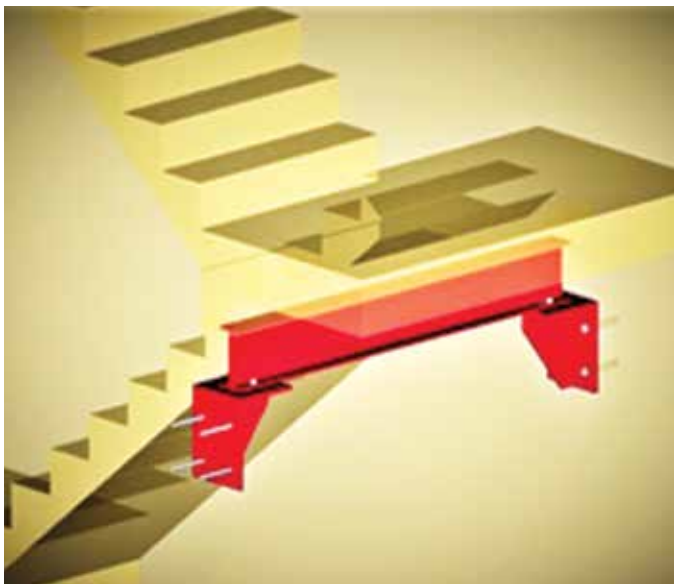


Figure 2: 3D View of proposed moveable staircase support bracket

thority (ERA), a recently convened panel of ASR experts agreed that the current rate of expansion is observed to be slowing down. They further agreed that there is no sign of sudden failure or high deformations for the next 30 years. Naturally this does not mean that there are no interventions required in the next 30 years. On the contrary, there is a clear road map of short-term and long term interventions that will be undertaken in order to further extend the life of the plant. The power station operator EUL, has designated a large capital expenditure as part of this road map to further mitigate any risks, with planned efforts such as dam grouting, installation of generator floor support structures, crane modifications and instrumentation upgrades which shall be done to further increase the life of the power plant.

The lessons learned and experiences from the ASR movements, studies and intervention efforts have and continue to contribute to improved design and maintenance concepts that will ensure the sustainable growth of the nation's large infrastructure such as the dams and bridges. Key to these lessons is the overwhelming need for comprehensive material testing prior to construction of such large structures. This way oddities such as ASR can be prevented. Implementing a systematic and robust structural health monitoring program along with detailed investigations, studies and engineering analysis, go a long way in proactively identifying structural risks and providing information to design lasting remedial solutions. Last but not least is the importance of executing timely and well researched remedial actions to provide positive life extension to such infrastructure. When it comes to being thorough, experience has taught EUL that performing just one more study to confirm results, goes a long way in avoiding decisions that could be detrimental to the long term plant health.

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Figure 3: Before and after images of specialized underwater diver remedial repairs at Nalubaale in 2019

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We can revolutionize the building industry with post-tensioned concrete

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Roderick Obeja is a civil engineering graduate member of the Uganda Institution of Professional Engineers and is involved in the design and delivery of post-tensioned structures. He works with Questworks Limited, www.questworks.co.ke, a design-build (engineering, procurement and construction) firm focused on turn-key delivery of real estate and renewable energy projects in Africa. Questworks is engaged in the design and construction of post-tensioned concrete structures, and is headquartered in Nairobi.

The *American Concrete Institute* defines post-tensioning as "a method of reinforcing (strengthening) concrete or other materials with high-strength steel strands or bars, typically referred to as tendons." Concrete has a higher compressive strength in contrast with steel, whereas steel has a higher tensile strength compared to concrete. Pre-stressed concrete, of which post-tensioning (PT) is a part, uniquely uses the inherent compressive strength in concrete to provide additional structural strength in concrete structures. I have designed and delivered on several post-tensioned projects while working with Questworks Ltd, and I am confident that PT structures are stronger, more durable and economical in contrast with the traditional reinforced concrete (RC) counterparts because I see these benefits daily as I structurally design for PT and manage field installations.

The superior advantages provided by PT include: longer spans, reduced structural depths, watertight elements, crack-free slabs, improved deflection control and capacity under service loads, improved aesthetics due to optimised column sizes and locations, economical structural elements particularly in slabs and beams for spans beyond 7m. An in-depth understanding of the design and analysis of PT in concrete structures, and the quality in construction materials and processes are irreducible minimums in PT structures. If PT is adopted more in design and construction in East Africa, superior concrete structures, significant cost savings, aesthetically more agreeable structures will be realised, like has been achieved the world over. Structural engineers, and those prepared for the built environment briefly study pre-stressed concrete. It is not enough to know about these benefits; we need to actually design and build using these solutions we know about, and we can, if we want to.

My experience with PT has been in commercial and residential buildings, industrial developments, religious and institutional buildings, slabs-on-ground in expansible soils (like lack cotton soils), car parks, airstrips, bridges, transfer beams, aqueous structures, structural restorations, raft foundations.

Overview

Post-tensioned construction has a decisive technical and economic advantage over its counterpart and more traditional, reinforced concrete (RC). PT concrete is an innovative use of complementary materials: concrete and high-tensile steel. When steel is used to pre-compress the concrete, an advantage is introduced because concrete has a high compressive strength, which compensates for its low tensile strength (10% of its compressive strength). The combination presents a structural element with superior tensile and compressive force resistance properties. The surprising significant cost savings due to a myriad of factors which will be discussed in this trilogy, do not compromise on functionality, integrity, elegance, or durability. In fact, often, structures are more serviceable as a result of PT application.

The first PT building in East Africa is in Nairobi, and is the Strathmore University Sir Thomas More Building, completed in 2016, and designed and delivered by Questworks Ltd. The region has seen several pre-stressed concrete solutions applied mainly on bridges and civil structures, but rarely on buildings. Many practising structural engineers receive a very basic and cursory education in pre-stressed concrete, and hence will lean towards

reinforced concrete for all structural challenges, instead of applying pre-stressed concrete because in many ways, it is a very innovative structural solution. In addition, the precision required in PT construction is yet to be achieved in the construction industry. PT design and construction are an opportunity for firms which are keen to deliver quality and economy to clients and developers. It is time we became of age and more brave as engineers and clients to deliver economically, reaping from existing sound and innovative structural engineering applications.

Brief history

A patent for pre-stressed material was taken out in California in 1886, but it was only in the late 1940s that pre-stressed concrete really began to develop. The shortage of steel in Europe after the Second World War opened the way for use of pre-stressed concrete in the period of reconstruction that followed the war. Eugene Freyssinet, a Frenchman, is respectfully regarded as the 'father' of pre-stressed concrete. After much research throughout the early twentieth century, he managed to secure his first patent in 1928 and thus secured his theory of pre-stressing. His first publication on the subject was precisely entitled "*A Revolution in the Art of Building*". When Eugene developed and patented this technique of pre-stressing concrete, he little realised the applications to which his invention would be put in future years. Spectacular growth in the use of pre-stressed concrete took place after the Second World War in Europe to repair and reconstruct bridges. It is now a widely used and accepted civil engineering construction material. The first post-tensioned buildings were erected in the USA in the middle of the 20th century using un-bonded post-tensioning. Some post-tensioned structures were built in Europe quite early but the widespread and real development took place in Australia and the USA.

Pre-stressed construction has been used mostly precast bridges and some water tanks and dams in East Africa. The first post-tensioned building in East Africa is the Strathmore University Sir Thomas More Building in Nairobi, where the suspended floor slabs are constructed exclusively using post-tensioned concrete, with both design and construction done by a single regional company, born, bred and buttered in Kenya, with activities in the region. Today, the entire world has used some form of pre-stressing in concrete construction, and it is hoped that pre-stressed concrete will gather the moss on the African continent. South Africa leads all Africa in the use of PT. Can we not catch up as a region? What are we afraid of? Do we not know and can we not apply this innovative structural solution? Yes we can!

Principles

Pre-stressed concrete is simply pre-compressed concrete. A compressive stress is applied into a concrete member before it begins its working life and is positioned in areas where tensile stresses will develop under working load. We are concerned about tensile stresses because although concrete is strong in compression, it is weak in tension. Steel is strong in tension, and weak in compression. In pre-stressed concrete, the compressive stresses introduced into areas where tensile stresses develop under load will resist or annul these tensile stresses. The concrete will then behave as if it had a high tensile strength of its own and, provided the tensile stresses do not exceed the pre-compression stresses, cracking cannot occur at regions of high tensile stresses.

In daily life, the fundamental principle of pre-stressing is applied by a person moving several books, perhaps in a library, by hand. As an alternative to stacking them vertically, one on top of another and supporting them underneath, they can be lifted and moved in a horizontal stack, by exerting pressure (through a compressive force) with a hand on each end. In fact, the higher the compressive force, the more bricks can be supported; even more bricks can be placed on top of the horizontal stack. This is simply the principle of pre-stressed concrete.

The American Concrete Institute describes pre-stressed concrete as "concrete in which there have been introduced internal forces of such magnitude and distribution that the forces resulting from the given external loadings are counteracted to a desirable degree".

Two methods exist where pre-stressed concrete is applied: pre-tensioning and post-tensioning. Pre-tensioning as the word implies, is where the steel is tensioned between abutments and then concrete is placed in forms around it. When the concrete has achieved sufficient compressive strength, the steel is released from the abutments, transferring the force to the concrete through the bind that now exists between the steel and the concrete.

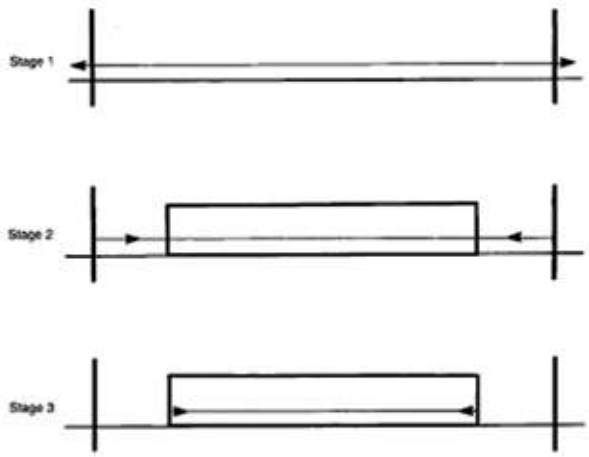

Figure 1: Pre-tensioning stages, courtesy "An Introduction to Pre-stressed Concrete, A H Allen"

In PT, the concrete is cast first in forms, allowed to set, before the pre-stress is applied. The steel is usually placed in position in a predetermined profile, and the concrete cast thereafter, or ducts can be created in the concrete, and the steel passed through thereafter. PT concrete can be bonded or un-bonded, both with critical differences and advantages. Bonded PT occurs where the concrete has a bond with the post-tensioned steel member through a cement grout between the PT steel and the concrete, while un-bonded PT is where a sheath exists between the concrete and the PT steel.

PT concrete slabs have varied advantages over the reinforced concrete slab counterpart and other structural systems for both single and multi-level structures:

a. Longer spans can be used, hence reducing the number of columns, resulting in larger, column free floor areas, there by greatly increasing the flexibility of use for the structure and resulting in higher rental incomes.

b. PT has a favourable influence upon deflections of slabs under service loads compared to RC. Undesirable deflections under service loads can be virtually eliminated and deflection capacities increased for significant spans.

c. The total cost of materials, labour and formwork required to construct a floor is reduced for spans greater than 7 metres, hence providing superior economy and durability. This also provides for a reduced carbon footprint.

d. For the same imposed load, thinner slabs can be used, allowing additional building heights for the same maximum building height with resultant savings in façade costs. For taller buildings, it allows for more floors to be constructed within the original building envelope.

e. PT slabs are virtually waterproof, depending on good and careful design, detailing and construction.

f. PT floor slab construction is faster with earlier stripping of formwork, reduced back propping requirements, enabling faster construction cycles and quick re-use of formwork.

g. PT floor construction requires less material handling, and benefits on-site carnage requirements. The strength of PT strands is approximately four times that of conventional reinforcement, hence reducing the total weight of reinforcing material.

h. Reduced floor dead loads are greatly beneficial for columns and foundations with reduced column and foundation sizes and requirements. With reduced columns, the net floor area available for rent is increased.

i. A combination of the above benefits provides increased durability in structural elements.

Post-tensioning does require a sound structural design (typically using the finite element analysis method), and skilled and trained field personnel, with appropriate equipment. Clients currently pay more for structures, and better economy can be obtained through solutions like PT. At Questworks Ltd, we will continue to provide the best solutions to the market, and are happy to continue to advance technologies that are stronger, more durable and economical. We are happy to provide clients with solutions, and to work with everyone in the built environment toward the best solutions in Uganda.

Figure 2: 14000 m2 PT on ground, Vivo Energy Kenya Petroleum Depot, Nanyuki, Kenya

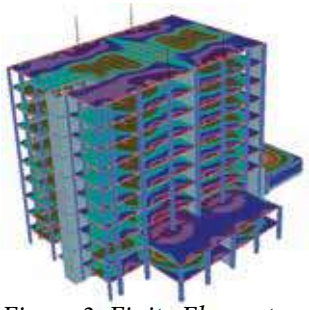

Figure 3: Finite Element Method of Analysis for Post-Tensioned Building, for a project in Nairobi

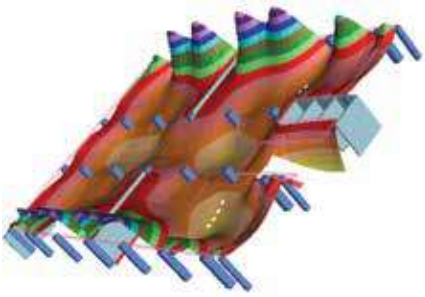

Figure 4: Deflection check from Finite Element Analysis of a slab panel, for a project in Nairobi

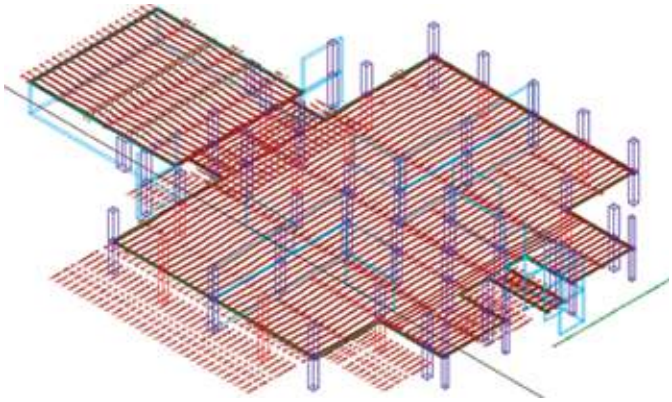

Figure 5: Arrangement of PT strands on a slab panel for a project in Nairobi

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" You Come As A Guest And Leave As A Friend"

USMID ACCELERATES MUNICIPALITIES INTO FUTURE CITIES

In this abridged question-and-answer interview, Eng Dr Isaac Mutenyo explains how USMID (Uganda Support to Municipal Infrastructure Development) is accelerating the growth of municipalities into cities.

Who is Isaac Mutenyo among engineers and at USMID?

Eng Dr Isaac Mutenyo, a past President of the Uganda Institution of Professional Engineers (UIPE 2014-2016), is the coordinator of the Uganda Support to Municipal Infrastructure Development Program (USMID) under the Ministry of Lands, Housing and Urban Development.

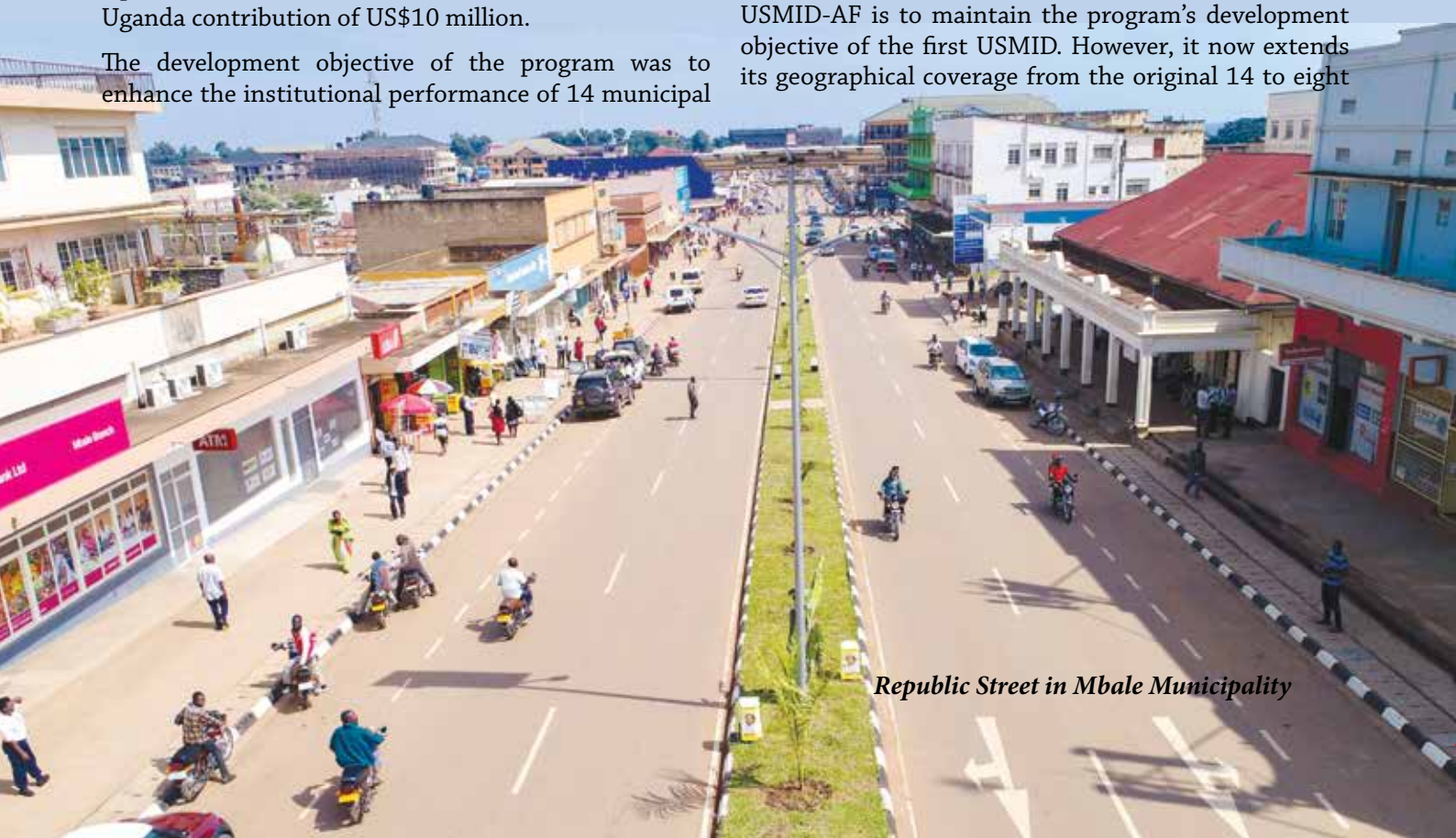
What is the USMID program?

USMID was a five-year program (2013 to 2018) that was implemented with a World Bank/International Development Agency (IDA) credit of SDR 97.4 million equivalent to US$150 million and a Government of Uganda contribution of US$10 million.

The development objective of the program was to enhance the institutional performance of 14 municipal local governments for the betterment of urban service delivery. In addition to infrastructure development and capacity building of the participating municipal local governments, the program was to provide capacity building to the Ministry of Lands, Housing and Urban Development (MLHUD) to enable it to perform its mandate of urban development effectively.

After its successful implementation, Government received additional financing to the tune of US$360 million also from the World Bank/IDA to implement the second phase of the program (USMID Additional Financing-USMID-AF) for five years starting in the financial year 2018/19.

USMID-AF is to maintain the program's development objective of the first USMID. However, it now extends its geographical coverage from the original 14 to eight



Republic Street in Mbale Municipality

Eng Dr Isaac Mutenyo

additional municipal local governments of: Kitgum, Kamuli, Mubende, Kasese, Busia, Ntungamo, Apac and Lugazi, and adds on eight refugee hosting district local governments.

USMID started in the financial year 2013 ending in 2018. It is understood that there is a new one with increased funding. Why did you not complete the program, and why is there increased funding?

The USMID program that started in 2013 was actually completed in December 2018 with an 100% performance and funds disbursement. It had however been realized at midterm review of the program in 2016 that the urban infrastructure gaps were enormous and little impact would be created with only a 150-million-dollar funding. At that time, Government and the World Bank agreed to have additional financing to build on the achievements made. Therefore in 2019 we started on the USMID-AF program.

There are many municipalities in Uganda. What was the criteria for selecting the initial 14 as beneficiaries of USMID? Who are the next beneficiaries and what criteria did you use to select them?

Currently there are 41 municipalities in the country. The funding required to provide the requisite municipal infrastructure is enormous. So, Government had to make a decision on how to cause meaningful impact, by phasing the development. The first consideration was the conventional regional municipalities: Gulu, Arua, Lira, Tororo, Moroto, Soroti, Mbale, Jinja, Masaka, Fort Portal, Mbarara, Kabale, Entebbe plus Hoima (for its oil-induced development). These were part of USMID and will continue under the USMID-AF program. Next consideration was population and regional balance, which brought forth the most populated municipalities in the northern, eastern, western and central regions. When added together, all these total to 22 that will be implementing and benefiting from the program until 2023.

In addition to the 22 municipalities of the program, USMID-AF will support urban centres and their wider district local governments in eight refugee-hosting districts of Kiryandongo, Yumbe, Kamwenge, Lamwo, Arua, Isingiro, Adjumani and Moyo. The support under this window of the program will be in form of physical planning of the refugee-hosting communities' land, enhanced land tenure security for both the host communities and refugees, and infrastructure investments.

Ring Road in Gulu Municipality

Is it true that USMID is accelerating the growth of municipalities into future cities? How?

USMID aims at improving urban service delivery. It is the improved services that provide the best indicator of growth of an urban area. USMID has contributed tremendously in this regard: take a look at the municipalities that received significant resources from USMID like Gulu, Arua, and others. These have transformed into cities. Indeed, due to the support from USMID, nine out of the 14 municipalities have been elevated to city status. That is quite an achievement.

Explain how USMID identifies the needs, procures consultants, designs, procures contractors and supervises the works?

Infrastructure sub-projects are prioritized by the municipal local government from their physical development plans and their five-year development plans. Prioritization is done in consultation with municipal development fora (MDF). The MDF is a citizens' engagement mechanism that brings together different categories of dwellers in the urban centres to plan and monitor the development initiatives in their urban areas.

The prioritized projects are then submitted to the USMID team offices in the Ministry of Lands, Housing and Urban Development for verification and approval. The ministry then procures design consultants who undertake all designs and the necessary documentation for contracting civil works contractors. Once the design and documentation are complete, the ministry makes these available to the USMID Program local governments and clears them to commence procurement of civil works contractors and supervising consultants. Procurement follows the Government's established PPDA laws, guidelines and regulations; but as a ministry we offer technical support and guidance throughout the procurement and contract management.

A section of the public complains that they are never shown planned/designed works, so that they can positively criticize or audit the works in progress. Is this true? If yes or no, explain.

The sub-project identification, prioritization and engineering design processes are very transparent and interactive. There is a criterion used for approval of projects to be funded, which include; available resource envelope to the local government, the economic importance of the project, the number of beneficiaries, no encumbrances on the proposed sub-project (eg land conflicts, compensations, environmental impacts, disturbances to the community, etc) that are considered. Once these considerations are made, the design follows a back-and-forth process through the feasibility studies, preliminary designs and detailed designs. The Technical Planning Committee (TPC) of the local government meets on a regular basis with the design consultants to discuss design as it unwraps so that by the time of final designs, everyone is informed. The artistic impressions of each project are always displayed at the council offices, contractors' site offices, and consultants' offices. Documents are all available at the municipal engineer's offices and the town clerk. We have noted though that display is not done well sometimes and this is an area we intend to improve on.

What are the successes of the outgoing program, if any?

The first USMID Program registered tremendous success. That was the background from which an additional financing phase was approved, for another five years.

One of the outstanding indicators of our performance was the elevation of the municipalities where USMID was to cities. This is evidence that the municipalities (now cities) had developed and beautified their infrastructure projects and their capacity to have their own resource revenue as an indicator of their ability to manage their affairs at city status.

The total population of beneficiaries in the 14 program municipalities was 1,327,100. Below are some of the successes, among many others:

Roads:

- A total of 110 urban roads totalling about 78.4 km were constructed in 13 municipalities.
- Approximately 93.2 km of covered line drains and 30.3 km open drains.
- 100.2 km of pedestrian walkways, 21.8 km of cycle lanes, 43.5 km of parking lanes
- 2,807 solar street lights
- 1,114 street trash cans
- Signalized traffic lights at a junction in Mbale Municipality

Environment:

- Improved 65,365 sq m of green space
- Planted 2,431 trees

Local economic infrastructure:

- 3 taxi parks complete with 328 lock-up shops and 143 vehicle/taxi parking lots & restaurants in Arua, Tororo and Entebbe Municipality
- 1 bus terminal with 16 bus bays and 32 lock-up shops in Moroto
- 1 lorry park with 14 lock-up shops in Fort Portal Municipality
- Improvement of Coronation Park in Lira.

One major problem with government borrowing is failure to use part of the funds to enhance local capacity of the local consultants, contractors and graduates. Does the USMID program have this component? If yes or no, why or how does it work?

Borrowed funds have to be used in accordance with the financing agreement between the funder (in our case, the World Bank) and the borrower (Government). Some of the provisions in these financing agreements do not allow restricting contracts to local providers and the World Bank is one of those. The opportunities to access World Bank-funded contracts are available to all eligible providers in all member countries. However, under USMID, local consultants took up all the supervision consultancies through competitive bidding, and to us this is a plus. In addition, however, we have agreed with the World Bank that in response to the local content policy of Government, where foreign firms win civil works contracts, 30% of the works shall be subcontracted to local service providers. We hope this will help in building the capacity of local firms both as consultants and contractors. We have also made a provision to attach young graduates (engineers, environmentalists, sociologists) to contractors and consultants as a means of training and skills transfer.

What will you do better in the new USMID Program than in the outgoing one?

We will improve on our communication and information dissemination to the public. In the last five years, one of the things we realized was that the public in the USMID-funded local governments didn't have enough information to help them be part of the oversight function. This we shall improve; already we have started making available all the program information to all the relevant stakeholders through public awareness campaigns, IEC materials dissemination and formal citizen engagements. We also keep engaging with the municipal leaderships to make all information public, because an informed populace is vital in such projects.

Further, we will standardize designs of urban infrastructure by supporting the Ministry of Works and Transport to update the urban roads manual, among so many other things.

Your message to our readers?

Elevation of some municipalities to cities has caused excitement. However, people should be mindful of the challenges that come with managing and maintaining a high standard of urban services in cities. In the current form, none of the elevated municipalities has that capacity. More resources will be therefore required, reforms in the institutional set-up will need to be changed and also revenue regimes must be enhanced. USMID-AF will make some proposals on how to transit the elevated municipalities to cities. The Lands, Housing and Urban Development sector will play a pivotal role in this.

Smart grid will take Uganda to next level

By Eng Jimmy Noel Sande Oola
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Jimmy is a graduate of Makerere University holding an MSc in Power Systems Engineering, a BSc in Electrical Engineering and a Postgraduate Diploma in Project Planning and Management from the Uganda Management Institute (UMI). He is a member of the Uganda Institution of Professional Engineers (UIPE), the Institute of Electrical and Electronic Engineers (IEEE), and a Registered Electrical Engineer in Uganda.

Eng Oola started his career as a graduate trainee electrical engineer at Tororo Cement Industries in August 2001. He later on joined the Uganda Electricity Distribution Co. Ltd (UEDCL) in September 2002 and then Umeme Limited where he worked in different departments, namely Substation Maintenance, the Loss Reduction Unit, Metering Technology, District Operations (at Bombo and Natete), and Planning. Jimmy is currently still with Umeme Limited, working as a planning and design engineer based at Lugogo.

Abstract

Information Communication Technology has played a very vital role in the development of electricity distribution which has given customers options in payment methods and access to information using Automated Metering Reading. The achievement of a smart grid will enable two-way communication and this will be possible with support from the Electricity Regulatory Authority. Uganda currently has eight electricity distributors in different regions of the country. A smart distribution grid employs the geographic information system, supervisory control and data acquisition, advanced metering infrastructure, advanced distribution management system and smart grid enterprise integration.

Keywords: Smart grid, ICT, AMI, network

Introduction

In this era of the Fourth Industrial Revolution, technology has taken over many sectors. For instance, there was analog to digital migration for television; telecommunication companies introduced mobile money; banks introduced internet, mobile and agent banking; the transport industry introduced Safe Boda, Uber, etc. The electricity sector has not been spared with advancement in technology.

Uganda's electricity sector

In 1938, a licence for thermal generation and distribution was issued to the East African Power and Lighting Company to start electricity services in the towns of Kampala, Jinja and Entebbe (Mawejje, Munyambonera, & Bategeka, 2013).

In 1948, the Uganda Electricity Board was created to oversee developments in generation, transmission and distribution of electricity. Due to political unrest, there was a near collapse of the electricity sector in Uganda and in 1993, major reforms led to the divesture of many public enterprises (Mawejje, Munyambonera, & Bategeka, 2013).

The electricity sector in Uganda was liberalized following the enactment of the Electricity Act, 1999. This led to the unbundling of the Uganda Electricity Board (UEB) and the creation of successor companies: the Uganda Electricity Generation Company Limited (UEGCL) which manages electricity generation, the Uganda Electricity Transmission Company Limited (UETCL) which manages electricity transmission, and the Uganda Electricity Distribution Company Limited (UEDCL) which manages electricity distribution (Electricity Regulatory Authority, 2018). Figure 1 shows the different stakeholders in the sector.

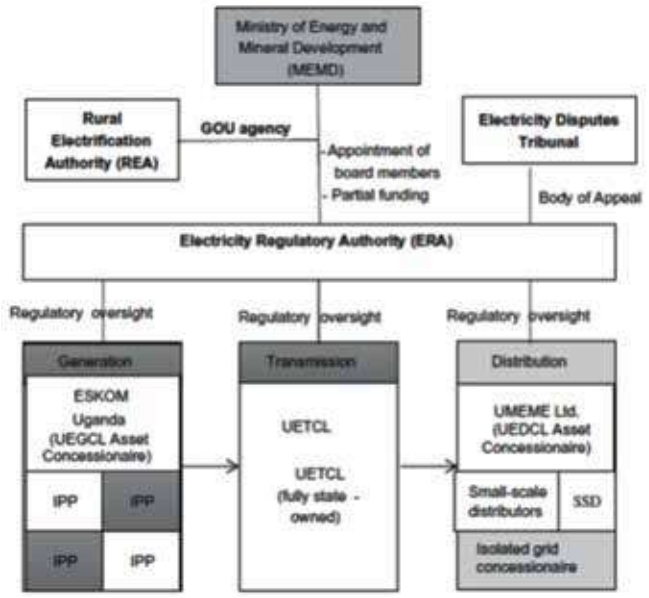

Figure 1: Structure of Uganda's Power Sector; Source: (Meyer, Eberhard, & Gratwick, 2018)

Smart Electricity Distribution Grid

What is a smart grid?

The Institute of Electrical and Electronics Engineers defines a smart grid as a next-generation electrical power system that is typified by the increased use of information and communication technology (ICT) in the generation, delivery and consumption of electrical energy (Gass, Echeverría, & Asadollahi, 2017).

A smart grid is the evolution of the traditional electric grid by applying technologies, tools and techniques to bring knowledge to the electric systems for better performance. One of the technologies is Advanced Metering Infrastructure (AMI) which makes the electricity industry more consumer interactive (Cespedes, Parra, Aldana, & Torres, 2010).

The need for a smart grid

A smart grid will ensure a more reliable and quality power supply to customers. The power sector can go green by lowering greenhouse gas emissions through the efficient integration of renewable energy sources (Mahesh, Nandgaonkar, Nalbalwar, & Pradnya, 2012, p. 34).

The challenges that a modern electricity network faces include privacy, cyber security threats, alternative power generation sources, high quality and interrupted power supply, and electronic loads. These challenges require an intelligent, self-balancing and integrated electric network that uses information and communications technology (ICT) to manipulate and share data (Luca, Giuseppe, Giuseppe, & Maurizio, 2013).

Smart grid development is an enhancement of the existing network by means of implementing new services. The functions that a smart grid must provide include self-healing, consumer participation, high-quality power, support for different types of storage and generation, and higher efficiency (Luca, Giuseppe, Giuseppe, & Maurizio, 2013).

3.3 Smart grid building blocks

There are five building blocks to achieve the business objectives of smart grid implementation.

- Geographic Information System: GIS enables the proper operation of smart grid components, such as OMS (Outage Management System) and DMS (Distribution Management System) for real-time system management, as well as informs other applications for system planning and engineering.
- SCADA: SCADA is a centralized system for real-time data acquisition, monitoring and control of remote equipment. There are sensors and other devices installed on the network for assessing its state.
- Advanced Metering Infrastructure: AMI is a system that collects, measures and analyzes energy usage over a two-way communication network connecting smart meters and the utility's control systems. It allows remote meter reading, connection-disconnection, theft-tamper detection, outage management and distributed generation management.
- Advanced Distribution Management System: ADMS is a collection of applications designed to monitor and control the entire distribution side in a power network.
- Smart Grid Enterprise Integration: Information Technology (IT) is associated with back-office information systems relating to accounting, billing and revenue, workforce records, etc. Operation Technologies (OT), on the other hand, include software applications that provide operational control of assets in the electric network in real time.

Figure 2: The building blocks of a smart grid source: (Sujay, 2017)

3.4 Smart grid development and implementation

The reasons for converting from the conventional to the smart grid include increased energy demand, reduction of technical & commercial energy losses and increased power production from renewable energy sources (Gang, Zhong, & Fenghua, 2012).

The overarching technological components of AMI include smart meters, communication network, meter data acquisition system and meter data management system (India Smart Grid Forum, n.d.). "The key objective of smart grid initiatives are focused on modernizing the distribution grid with advanced automation and control features" (India Smart Grid Forum, 2017).

Advanced Metering Infrastructure (AMI) is the basic building block of Smart Grid. It enables users to participate in energy management processes. Use of smart meter data will improve efficiency of the distribution utility and provide quality power to consumers (Jha, Sen, & Agarwal, 2014).

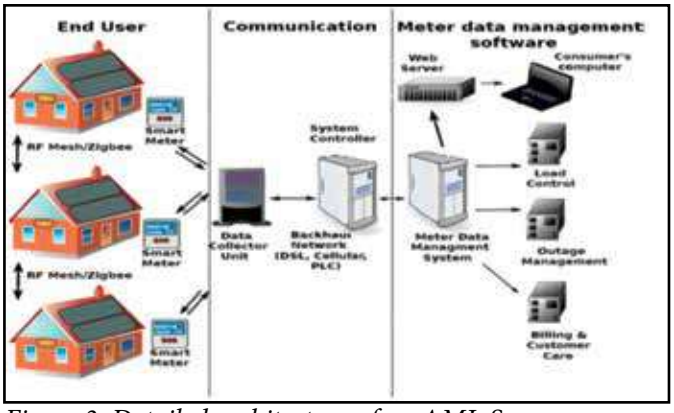

Figure 3: Detailed architecture of an AMI; Source: (Gungor, et al., 2013)

Many changes have occurred within the electricity distribution business in Uganda, especially with reference to Umeme, the largest distributor. There was closing of cash offices with introduction of various payment options e.g. banks, mobile money, payway, mobile application, etc. Analog three-phase meters were replaced by digital meters, Automated Meter Reading (AMR), etc. Introduction of prepayment where customers pay upfront before using electricity just to mention some of the technological achievements. Figures 4 and 5 indicate the progression in energy metering over the years.

Figure 4: Three-phase energy meters

Figure 5: Single-phase energy meters

Conclusion

This paper looked at the developments in the electricity sector in Uganda and the different players as regulated by the Electricity Regulatory Authority. The advancement in technology has led to consumers demanding more services from utilities. In this regard, the smart grid is envisaged to achieve this. Umeme, which is the largest distributor, has been progressing in attaining a smart grid though a lot is still required for this dream to be realized.

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MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION (MoSTI)

The Next 10 years:

National Actions for Scientific & Technological Development

Part A: MoSTI at a glance

The Ministry of Science, Technology & Innovation (MoSTI) was established in 2016 as the lead sector agency and is mandated with providing overall policy guidance and coordination for scientific research, and development of the entire National Innovation System.

The ST&I sector is expected to play a key role in the achievement of the Uganda Vision 2040 goal of moving Uganda into the upper middle-income country category by driving the scientific and technological transformation for industrialization, competitiveness and employment creation. To achieve this, the ministry will focus on the following broad areas:

A. Strengthen S&TI sector policies, planning and coordination.

The Ministry will enhance actions for improved collection of ST&I data, information and analysis for evidence-based planning and policy making; Improved policies & strategies; and improved sector coordination. This is aimed at anchoring ST&I into the national development processes.

B. Develop STEI support infrastructure

The Ministry will establish Science, Technology, Engineering and Innovation (STEI) physical infrastructure, associated programming and institutional support systems that needs to be put in place for the infrastructure to be effective and sustainable. These include investments in ST&I business incubators, science and technology parks, technology transfer centres, municipal technology and innovation hubs, materials and nanotechnology institutes, advanced research facilities at universities and research institutions and science promotion centres.

These facilities will provide improved technologies, shared user support services, skills training, comprehensive support to product development and product/service commercialisation.

C. Scale-up National Science, Technology and Engineering Human Capital Development

The focus is to address existing constraints with respect to Science, Technology, Engineering and Mathematics (STEM) practical skills development, training, pedagogy, apprenticeship and curriculum. Furthermore there are deliberate efforts to strengthen STEM human resource development and orientation in primary schools, secondary schools, tertiary institutions, vocational institutes and universities. The multipronged approaches currently under implementation for advanced practical skilling include:

- The Machining and Manufacturing Industrial Skills Training center under development in Namanve by the Uganda Industrial Research Institute (UIRI), an agency under the Ministry.
- National Science, Technology and Engineering Skills Enhancement Centre (NSTESEC) - Sanga, and Technology Innovation and Business Incubation Centre (TIBIC)-Namanve, spearheaded by Uganda National Council for Science and Technology(UNCST), an agency under the Ministry.
- Development of a dual educational system that integrates formal and vocational education model.

D. Strengthen R&D capacities and applications in existing and emerging fields of science and technology

The Ministry will support development of basic and applied scientific research capacity, indigenous technological innovations and new emerging areas of STI like nanotechnology.

Dr. Elioda Tumwesigye
Minister

Mr. Obong O. O David
Permanet Secretary

The Government of Uganda established a Ministry of Science, Technology and Innovation (MOSTI) on recognizing Science, Technology and Innovation (STI) are the drivers of socio-economic growth and transformation the world over. Technology and Innovation development is an important determinant of progress and transition.

MISSION

To provide leadership, an enabling environment and resources for scientific research and knowledge based development for industrialization, competitiveness and employment creation leading to a sustainable economy.

MANDATE

To provide leadership, an enabling environment and resources for scientific research and knowledge based development for industrialization, competitiveness and employment creation leading to a sustainable economy.

VISION

A scientifically proficient and technologically advanced innovative society.

The Hon Minister, Permanent Secretary, Directors and staff of the Ministry of Science, Technology and Innovation congralutate The Engineers Registration Board (ERB) and the Uganda Engineers Fraternity on celebrating their Golden Jubilee (1969-2019)

Ministry of Science, Technology & Innovation
Plot 19, Lumumba Avenue, Rumee Building, P.O. Box 7466, Kampala Uganda
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Email:info@mosti.go.ug

E. National Space Programme

The ministry through international and bilateral technical cooperation and programmes with Russia, Israel, and Japan is developing the National Space Programme with the objective of launching a satellite by end of 2022.

F. National Research and Innovation Programme

The Ministry is leading efforts in mobilizing public financial flows to ST&I sector through the National Research and Innovation Programme Framework and also developing complementary funding portfolios from private sector to target ST&I startups and businesses.

G. Public investment in viable science & technology enterprises

The Ministry will intensify public financial and technical investments in science and technology driven firms to enable them successfully and sustainably develop their respective innovations and technologies from ideation phase to full-scale commercialization ensuring innovation and technology uptake and enterprise development. Key projects under industrial development include; Kiira Motors Corporation (KMC) and Banana Industrial Research Development Corporation (BIRDC).

Part B: How these actions will intersect with engineering and engineering projects

STEI has been recognised in the National Development Agenda as one of the critical fundamentals that must be strengthened to transform Uganda into a modern and prosperous country towards 2040. STEI is critical because it cross cuts not only the other identified fundamentals like infrastructure, land, human capital development, and defence and security; but also virtually all the sectors of the economy.

As this transformation takes shape, a number of flagship engineering projects have either been completed or are under development – including Hydro-Power Dams, Transmission Power Lines, Entebbe Express Way, Northern Bypass, Greater Kampala Mass Transport System, Standard Gauge Railway, Revival of Uganda Airlines, Oil & Gas Infrastructure, to mention but a few.

Whereas these projects have increasingly benefited from local materials' input, there is room for further contribution and enhanced local content, so much so, with the intentional strengthening of local Research, Development and Innovation (RDI) capabilities. The national materials and nanotechnology program under development by the Ministry (MoSTI) combined with the Namanve Machining and Manufacturing Center will enhance value addition and increased use of local materials. RDI facilities will further support efforts geared at addressing challenges faced in geotechnical and materials testing, which is a critical quality management tool for these engineering projects.

Secondly, collaborations to enhance the national STEM skills and competences across the different skill sets for engineers, technologists, scientists and technicians will be important not only for engineering projects but also for the national engineering index. The combination of these STEM skills is increasingly required across a broad range of sectors.

Thirdly, MoSTI is fast tracking the development of the National Space Program. The main objective is to explore and exploit Uganda's capabilities and opportunities in space. Space capabilities like satellite imagery and accurate positioning services are enabling effective infrastructure management, as well as efficient mobility and transit in other countries. Increased application of technology can greatly benefit research and planning. For example, technology is advancing to place roads as a source of electricity from heat trapped in black tar surfacing asphalt material, which could power smart junctions and charging electric vehicles. This would be a typical example where STEI combines to deliver futuristic designs in the road sector.

As these STEI interventions progress, new science and engineering disciplines also continue to emerge, and contend with the traditional disciplines that have historically prevailed in the country. These disciplines will need to be developed. Such disciplines as aerospace, materials, Nono engineering, bioengineering, nuclear, manufacturing and design, genetics, mechatronics and robotics, among others, are a case in point. Collaboration between professional associations and policy leadership will be important to catalyse, support and sustain this development.

Linked with some of the emerging disciplines and technologies, is the concept of the 4th Industry Revolution (4IR) – which is the theme for this 2019 ERB Annual Forum. Whereas 4IR promises numerous benefits to society, it also poses potential challenges and risks. Notwithstanding, 4IR is anticipated to drive convergence of disciplines and technologies, and by implication, the future of engineering projects. Therefore, from a policy perspective, there is need to develop evidence-informed, responsive and future-oriented policy framework for these changes.

Looking at the last 50 years of Engineering, and projecting the horizon towards 2040, there is need to marshal structures of collaboration between the National STEI stakeholders; to not only enhance the country's Engineering, Technology and Innovation indices; but also deploy RDI capabilities to enhance the quality and sustainability of engineering and engineering projects. In addition, there will be need to work together towards the development of clear policies, regulations and standards to support the transfer, reverse engineering and local production of appropriate engineering technologies. The 4IR engineer will need to be scientifically proficient, technologically advanced and continuously innovative.

"Creativity is thinking up new things. Innovation is doing new things."

Theodore Levitt

Is the Direct Cone Penetrometer still justified in this Digital Age?

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Abstract

As the Fourth Industrial Revolution takes shape, like any other professionals, engineers continue to ponder what is to become of them. Whereas no one may be in position to speak with confidence and authority about what to expect, what seems certain is that our life experiences will not remain the same. Data handling capabilities are expected to improve exponentially, thereby blurring the gaps between the physical, biological and digital spheres. Consequently, machines (robots) may completely replace humans in many aspects of life, owing to the need for enhanced speed and efficiency of operations. In the areas of, say, geotechnical engineering where replacement of humans is highly unlikely, the need for quick decisions and innovations to match new technologies is envisaged to dictate that quick, simple, affordable but reliable methods are deployed in suitability assessment of the ground for engineering applications. This article addresses the question of whether the Dynamic Cone Penetrometer which is steadily gaining popularity, especially in the developing world, is justified for shallow foundations design bearing capacity in the Fourth Industrial Revolution however simple, quick and affordable it may be.

Introduction

Engineering is the art and science of using the available resources to satisfy human demands. The level of the art and science as well as human satisfaction is dependent on the development status in a given region or the industrial revolution in which one lived. Prior to the First Industrial Revolution which saw water and steam as the production energy source, stone, bronze and iron respectively formed the production raw materials. The Second Industrial Revolution then ushered in electricity, oil and gas as the major sources of energy and cars and aeroplanes were availed. The discovery of electronics, telecommunications and computers then marked the beginning of the Third Industrial Revolution. The Fourth Industrial Revolution is about the marriage between information and digital technologies.

Like the previous ages, the Digital Age is expected to change people's lifestyles and experiences. Given research developments, the increasing data handling capabilities are projected to narrow the gaps between physical, digital and biological spheres, something that is understood to unlock the potential of machines (robots and artificial intelligence) to replace humans in especially the labour market owing to the need for enhanced speed and efficiency of operations. Consequently, communication and the job market are among what is envisaged to undergo significant transformation. Many will lose jobs while others will register increased opportunities. As of now, however, it is uncertain as to which jobs will be lost to machines and which ones are not threatened. Generally speaking though, design and materials engineers are less likely to be negatively affected by the inevitable changes in the Fourth Industrial Revolution.

Recognizing the increasing popularity of the Dynamic Cone Peneterometer

(DCP) in in-situ assessment of shallow foundation design bearing capacity despite its limitations, this article focuses on whether its application is justified in the Fourth Industrial Revolution.

Procedure and principle of DCP test

During the test, a hammer is freely dropped repeatedly through a standard height onto an anvil attached to the rod with the cone at the end while measuring the penetration depth for each hammer drop or set of drops until the desired depth is reached. If the involved kinetic energy is high enough to fail soil in shear, the cone advances. Penetration of the cone into the soil, as a result of the imparted energy, is thus related to the soil strength. Guidelines for proper execution of the test are published in various sources including standards. One such standard is ASTM D6951/D6951M.

Interpretation of DCP data

In order to use DCP test results in the design of shallow foundations, the penetration results have to be converted into bearing capacity, directly or indirectly. Numerous equations exist for this purpose, hereunder discussed.

Direct equations

In an attempt to enable utilisation of DCP as a standalone device in the assessment of design-bearing capacity, several correlations between the penetration index (*DCPI*) in terms of the number of blows per 100mm penetration ($DCPI_{100}$) and bearing capacity (q) have been developed. Generally, the equations are of two forms: that of Equation 1 (e.g. Ampadu, 2005; Dzitse-Awuku, 2008) and the second of Equation 2 (e.g. Paige-Green & Du Plessis, 2009; Wilches et al., 2018). a and b are constants.

$$q = a + bDCPI_{100} \quad (1)$$

$$q = aDCPI^{b} \quad (2)$$

Indirect equations

For this category, Kasangaki, (2019) has shown that the general form of the equations (e.g. Black, 1961; Zumrawi and Elnour, 2016) is a power one as depicted in Equation 3 and that given CBR values bearing capacity is estimate-able. Luckily, it is possible to compute CBR from DCP test data using Equation 4. a, b and c are curve fitting parameters.

$$q = a(CBR - b)^{c} \quad (3)$$

$$\log_0 CBR = a + b \log DCPI \quad (4)$$

Remarks on the above equations

Analysis of the equations within a given category reveals that they are generally of the same form. This is interesting because then it means the framework of describing the relationship between the different sets of variables is well established. What remains is probably a quantitative understanding of the factors that control the fitting constants. Until such is done, the extensive testing programme to establish the most suitable equations or to calibrate any preferred equations is unavoidable.

Given that Equations 3 and 4 are of power and logarithmic form, respectively, Kasangaki (2019) and Kabazira (2017) have demonstrated that any small changes in the fitting parameters cannot be taken for granted.

It therefore means that the data analyst must be familiar with these aspects if any meaningful results are to be realised from the conversions. Where an unskilled inexperienced operator is deployed to conduct or oversee investigations, their level of under-standing may not guarantee meaningful results. Thus, care should be taken in selecting a person to oversee DCP testing and data analysis.

Limitations of the DCP test

Given the simplicity in carrying it out, the DCP test appears to be the obvious choice to many. Its execution is usually entrusted with unskilled inexperienced operators. This would not have been a problem if it was free of any limitations. Unfortunately, research has shown that the reliability of the DCP data is compromised by a number of factors. It worsens when even data analysis is left to such operators.

The dependence of DCP results on moisture content, particle size and distribution (Kleyn et al., 1982) and the friction factor (George & Uddin, 2000) is known. However, what is usually overlooked is the adoption of unsuitable equations. Having reviewed geotechnical investigations reports for various clients the author has observed that the use of the unmodified Terzaghi & Peck (1967) SPT data analysis equation to compute bearing-capacity from DCP data is common in Uganda. Although relationships between DCP data and the SPT N-value exist (Cearns & McKenzie 1988), the use of those developed purely for SPT or indeed any other test without calibration is risky.

With the above limitations, deployment of unsupervised, unskilled, inexperienced staff worsens the situation further. For instance, whether such operators can properly judge the soil moisture condition and particle size and distribution of the material or verticality of the device rod which leads to friction effects once penetrated in excess of 1.0m depth (Paige-Green & Du Plessis, 2009) without performing the relevant additional measurements is debatable, especially considering that the subsurface material being penetrated is not visible to the operator.

Lastly but not least, failure to incorporate the effect of geometric characteristics of the ground where the footing is to be constructed and those of the footing itself plus the nature of the load is another limitation. It is now common knowledge that the capacity of the ground to support footings is also influenced by the ground slope, the footing base slope, the footing depth, the footing shape and the load inclination, among others.

However, since DCP is more or less a vertical point test in comparison to the real footing size, it should be free of the effect of the aforementioned factors. The target then should be to have the factors individually accounted for in the developed correlations.

For as long as the above limitations are not addressed, it is highly unlikely that the DCP can yield reliable design-bearing capacity. In fact, by comparing cases where the test has been used together with other more reliable and established methods, Kasangaki (2019) has presented evidence of big departure of the predicted from the expected results. The departure notwithstanding, safe bearing capacity equations performed better than the ultimate capacity equations that were topped by Black (1961).

Conclusions

The purpose of this article was to make a case on the reliability of the DCP test in the assessment of design-bearing capacity. The major conclusions are as follows:

(1) At present, whereas there are numerous equations relating DCPI to bearing capacity, none of them gives reliable design-bearing capacity. The unreliability notwithstanding and topped by Dzitse-Awuku (2008), equations giving safe bearing capacity were better than the ones for ultimate bearing capacity within the range of about 500kPa. Thereafter, the reverse is true with Black (1961) as the best. Therefore, it is necessary for one to use only correlations they are sure of including features the DCP used in their development.

(2) Because the DCP test has several limitations, additional relevant routine tests on samples taken from the penetrated ground to supplement the DCP test are a necessity. It appears that for as long as the fitting parameters for the correlations are not related to the influential material properties, the reliability and adequacy of the DCP data for the design of shallow foundations will remain lacking. Accordingly, application of the DCP in the evaluation of design-bearing capacity in the Fourth Industrial Revolution is not justified.

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Quotes

"The more we think about how to harness the technology revolution, the more we will examine ourselves and the underlying social models that these technologies embody and enable, and the more we will have an opportunity to shape the revolution in a manner that improves the state of the world."

Klaus Schwab, The Fourth Industrial Revolution

THE APPROVED STRATEGIC DIRECTION FOR THE THIRD NATIONAL DEVELOPMENT PLAN (NDPIII)

The National Planning Authority was established by the NPA Act (15 of 2002) in accordance with Article 125 of the 1995 Constitution of the Republic of Uganda.

The mandate of the National Planning Authority

The primary function of the Authority is to produce comprehensive and integrated development plans for the country elaborated in terms of the perspective of the Vision and the medium-term and long-term plans.

In pursuance of its primary functions, the Authority carries out the following:

1. Coordinates and harmonizes development planning in the country;
2. Monitors and evaluates the effectiveness and impact of development programmes and the performance of the economy of Uganda;
3. Advises the President on policies and strategies for the development of Uganda;
4. Support the local capacity development for national planning, in particular, providing support and guidance to the national and local bodies responsible for the decentralized planning process;
5. Study and publish independent assessments of key economic and social policy issues and options, increase public understanding and participation in the economic and social policy debate;
6. Liaise with the private sector and civil society in the evaluation of Government performance and identifying gaps in government policies and programmes;
7. Reviews high priority development issues and needs and makes recommendations;
8. Ensures that all national plans are gender- and disability-sensitive; and,
9. Designs and implements programmes to develop planning capacity in local governments.

NPA's Vision

To be a centre of excellence for development planning, propelling socio-economic transformation.

NPA's Mission

To foster socio-economic transformation through establishing development planning systems and producing comprehensive and integrated development plans.

NPA Core Values

Professionalism, innovation, teamwork, partnership, and integrity.

The Second National Development Plan (NDP2) will expire in June 2020. This implies that NDP3 should be in place by May 2020. NDP3 is the third in a series of plans that aim to implement the Uganda Vision 2040 aspirations. In this regard, Cabinet on 9th September 2019 approved the strategic direction for the NDP3.

The strategic direction is the principal guiding framework for sectors and local governments in the development of their plans. It also enables NPA to engage the decentralized planning institutions (sectors, MDAs and local governments) to identify priorities that will eventually be consolidated in the National Development Plan as required.

Preliminary findings of the midterm review of NDP2 and the final evaluation of NDP1, as well as a synthesis of other studies on performance under NDP era (effective FY 2010/11) highlight several achievements and challenges. These include:

I. KEY ACHIEVEMENTS

1) The economy expanded more than two times, from GDP of UGShs46.9 trillion in FY 2010/11 to UGShs109.9 trillion in FY2018/19, in nominal terms. The GDP has expanded 12 times over a period of 21 years from UGShs9.5 trillion in

1995/96. Likewise, despite an increase in the population from 31.2 million in 2011 to 40.3 million mid-2019, the real GDP per capita grew by 16.4 percent from US$709 to US$825 over the same period.

2) The total export of goods and services grew from US$3.8 billion to US$5.4 billion over the NDP period (2010/11- 2017/18). This is a spectacular increment from US$347 million in 1986. Personal remittances grew from US$751.4 million in 2010/11 to US$1,245.7 million in 2017/18. Remittances were equivalent to 23.2 percent of the total export of goods and services in 2017/18. The import of goods and services increased from US$6.8 billion to US$7.8 billion over the period 2010/11–2017/18.

3) Electricity generation capacity increased from 610.0MW in FY2010/11 to 1,182MW in 2018/19 and should rise after commissioning of: Agago-Achwa II (42MW) in October and Karuma (600MW) in December 2019.

4) Due to the NRM Government's efforts to attract direct foreign investments, factories have increased from around 86 factories in 1986 to around 4,600 currently. Several industrial complexes are emerging in Namanve, Mbalala (Mukono), Kawempe, Matugga, and other areas. Factories have been established in food processing, iron and steel, ceramics, plastics, batteries, and many others. The number of cement factories has increased to four (4) operational plants in the country with a fifth (Sinoma Cement Factory in Mbale) being planned. In addition, Government has designated 22 areas for the establishment of serviced industrial parks.

5) Life expectancy rose from 43 years (men 42.5 and women at 43.5) in 1991 to 63.3 years in 2016. This means that life expectancy in Uganda increased by 20 years in one generation.

6) Maternal mortality ratio (per 100,000 live births) reduced from 506 in FY1986/87 to 336 in FY 2016/17.

7) Under-5 mortality rate (per 1,000) reduced from 147 in FY 1986/87 to 64 in FY 2016/17.

8) Average years of schooling increased from 2.5 in FY1986/87 to 6.1 in FY2016/17.

9) Following the introduction of Universal Primary Education, the gross enrolment in primary school increased from 3.1 million in 1996 to 7.6 million in 2003, and to 8.8 million in 2018.

10) Significant progress has been made in delivering key NDP3 flagship projects. For instance,

- The Isimba hydropower plant has been completed and launched,
- Karuma is undergoing testing before it becomes operational,
- The Entebbe Expressway is 95.6 percent completed,
- The Albertine region roads Olwiyo-Gulu-Kitgum-Mucwini and Kapchorwa-Suam roads are on schedule,
- Uganda Airlines is flying,
- The National Grid Extension including the Regional Power Pool is on schedule,
- Road Construction (Earth Moving) equipment has been completed and launched,
- The Phosphate Industry in Tororo is on schedule with phase 1 completed and launched,
- The Markets and Agriculture Improvement Project is on schedule with phase 1 subprojects completed and launched,
- Farm Income Enhancement and Forest Conservation is on schedule,
- The Entebbe Airport Rehabilitation is on schedule,
- ICT National Backbone Project is on schedule with phase 4 completed,
- The Entebbe Expressway is 95.6 percent complete,
- Renovation of 25 selected general hospitals is on schedule and due for completion by 2019,
- Construction of Kabale International Airport – Hoima is five months ahead of schedule.

II. KEY CHALLENGES

Despite the achievements so far, understanding and addressing the challenges is important in order to focus on the next phase of planning. Therefore, the

following challenges define the NDP3 focus for the next 5-10 years:

1. According to the Population Census 2014, a large proportion of the households (69 percent) obtains their livelihood from subsistence farming. They are self-employed in own farms and consume almost everything they produce. They are disconnected from the market and its benefits. NDP3 has to strategize to reverse this scenario.

2. The youth bulge (78% of the population are of age 30 years and below, representing 31.2 million people) creates both an opportunity and a challenge. It creates an opportunity because of the potential demographic dividend from cheap labour and future demand. However, if the youth bulge is not well-planned for, it creates a challenge and potentially missing the demographic dividend.

3. There is slow implementation of government projects especially because of delays in procurement.

4. Silo approach and duplications in delivering government services in hindering realization of results. Further, weaknesses in sector plans to fully align to NDPs for better budget alignment also limits full realization of NDPs.

III. THE PROPOSED NDP3 STRATEGIC DIRECTION

Based on the achievements, challenges and lessons learnt from implementing the NDP1 and NDP2, the NDP3 will build on the gains to provide the national strategic direction for the next five years. In developing the NDP3, the National Planning Authority is holding consultations with various stakeholders. The thrust of the NDP3 will be to reduce the subsistence nature of our economy through industrialization.

Therefore, the **goal** of the NDP3 will be "**Increased household incomes and improved quality of life**" while the **theme** will be **"Sustainable industrialization for inclusive growth, employment and wealth."** This will be achieved through **five** key objectives.

a FIVE OBJECTIVES OF NDP3

1) Enhancing value addition in Key Growth Opportunities (Agriculture, Tourism, Minerals, Oil and Gas, and Knowledge),

2) Strengthening the private sector to drive growth and create jobs,

3) Consolidating and increasing the Stock and Quality of Productive Infrastructure,

4) Increasing Productivity, Inclusiveness and Wellbeing of the Population,

5) Strengthening the role of the public sector in the growth and development process.

b NDP3 DEVELOPMENT STRATEGIES

To achieve the five objectives and effectively and efficiently implement NDP3, several development strategies have been identified through the reviews and consultations that were recently concluded.

1. **Maintaining Peace, Security and Good Governance**. This is the bedrock upon which development can thrive. The stability so far achieved will be sustained and zealously protected.

2. **Maintaining a stable macro-economic environment as an anchor of economic growth and development**. Beyond inflation targeting and forex management, emphasis will be on increasing savings, investment, capital formation and lowering commercial bank interest rates.

3. **Reducing the cost of doing business to attract foreign direct investment (FDI) and enhance competitiveness of domestically produced goods and services, both at local and international markets**. Priority will be on reducing the cost of power, transport, the internet, money, improving business processes, and zealously fighting corruption.

4. **Import Replacement and Export Promotion Strategy**. An import replacement strategy will be adopted to promote labour-intensive light manufacturing, cottage industries, heavy manufacturing for job creation and technology importation with the major objective of creating jobs for the youth. This will be key to build a sustainable export-oriented economy. Uganda is endowed with vast raw materials that could

help replace major imports such as: Petroleum, petrol products and related materials; Cereals and cereal preparations; Iron and steel, Fixed vegetable fats and oils, crude or refined; Paper, paperboard and articles of pulp or paper-board; Medical and pharmaceutical products; and plastics in primary forms.

5. **Commercialization of agriculture** to generate sufficient production volumes to sustain domestic (food security) and external markets. It is critical that we commercialize agriculture and agro-industrialize if we are to reduce the poverty levels in the countryside especially in the Eastern and Northern regions of the country.

6. **Harnessing the Tourism potential**. This is an area with quick wins, and in the NDP3 we propose to have a hybrid of both elite and mass tourism. We will focus on tourism skills, tourism infrastructure including water, land and air transport, as well as accommodation facilities especially in the least tapped areas. Branding and marketing Uganda will also be part of this package.

7. **Promotion of Science, Technology, Engineering, Innovation (STEI) and a Knowledge-driven economy.** This will entail STEI infrastructure development, training, policy and institutional framework development, standards development, collaboration and defining a National Research Agenda.

8. **Mineral Beneficiation and Oil refining**. This will involve fast-tracking the extraction and processing of confirmed minerals and exploration of minerals whose quantities have not been explored but highly suspected to be existent in Uganda.

9. **Revisiting the role of the Government in strategic areas of the economy**. In order to spur balanced growth in the country, and in the spirit of promoting Public Private Partnerships and the quasi-market approach, it is proposed that Government deepens its role in stimulating development.

10. **Promotion of Private Sector Investment (Domestic Investment and Foreign Direct Investment)**. This will be done through maintaining macro-economic stability, provision of long-term finance at affordable rates, reduction in the amount of domestic arrears and putting in place mechanisms to ensure that the costs of doing business in Uganda are kept low as well as strengthening the use of PPP arrangements. Branding and marketing Uganda will also be key in this effort.

11. **Mindset change to promote citizens' focus on development**. Ugandans have the potential of becoming more productive; however, they need a change of mindsets with a focus on development.

12. **Exploiting opportunities of Urbanization to drive growth**. This is important because 65 percent of non-agriculture GDP is generated by the Greater Kampala Metropolitan Area (GKMA), with Kampala generating 31 percent of the GDP. This potential needs to be harnessed.

13. **Improving the wellbeing and productivity of the population** by improving the quality of education and health service delivery; reforming vocational education; and increasing social protection through initiatives like health insurance schemes.

14. **Increasing Domestic Revenue Mobilization** Domestic revenue will be our main source of financing for NDP3. There is more potential, and significantly more revenue can still be generated through more efficient and effective tax administration by enforcing compliance and reducing tax evasion.

15. **Promotion of Social Services based on the Parish Model**. As we consolidate delivery of social services, it is recommended that the Parish becomes the Planning and Implementation Unit.

16. **Climate change adaptation and environmental management.** This strategy will focus on addressing issues of sustaining the rising population while addressing and managing the effects of climate change on livelihoods, incomes and prosperity.

These strategies will be implemented in a programmatic approach that strengthens sector synergies towards the realization of common results.

Petroleum Authority of Uganda

Enhancing Participation of Ugandan Entities in the High Value Engineering and Construction Contracts in the Oil and Gas Sector

Uganda's oil and gas sector has transitioned from exploration and appraisal to the development phase, in preparation for sustainable production of the petroleum resources that have been discovered in the country.

An estimated 6.0 billion barrels of oil resources have been confirmed in Uganda, with over 1.4 billion barrels recoverable, and close to 500 billion cubic feet of gas resources. Preparation of the already discovered oil fields for production is being undertaken under two separate projects, the Tilenga Project in Buliisa and Nwoya districts, and the Kingfisher Project in Kikuube and Hoima districts.

In addition, putting in place of infrastructure to commercialise the resources is being taken forward through the development of the Uganda Refinery Project and the East African Crude Oil Pipeline (EACOP) project.

The development and construction for the above-named projects is estimated to last for approximately 36 months from the initial mobilization and set-up to the commissioning/testing and final clean-up.

During this period, several facilities will be constructed in the Albertine Graben, which include:

i) Construction of approximately 42 well pads for Tilenga (35) and Kingfisher (7). The projects will involve civil works/earthworks and construction of platforms.

ii) Construction of two central processing facilities (CPFs), 250 kms of infield flow lines and the 150kms of feeder lines for both the Kingfisher and Tilenga projects

iii) Construction of a traffic checkpoint with 235 parking slots, warehouses, office and accommodation facilities

iv) Construction of water abstraction facilities

v) Civil works for the 29-sq-km Industrial Park whose scope includes earthworks, area fencing and drainage systems

vi) Design, construction and upgrading of over 662kms of road network

vii) Upgrade of various airfields with asphalt runway with landside facilities like the concrete apron, taxi lane, hanger, terminal building etc.

viii) Construction of a 60,000-barrel greenfield refinery

ix) Construction of a 213-km, 12-inch products pipeline

Construction of a 296-km, 24-inch insulated crude export pipeline (Ugandan part of the 1442.8km EACOP)

x) Construction of Uganda's second International Airport in Hoima, which is ongoing, at 32% of works completed.

xi) Other activities associated with the various infrastructure which will include technical surveys, land-clearing and grading, instrumentation and electrical works, fibre optic cables laying, construction camps, construction and upgrade of access roads, among others.

Layout of facilities for the Kingfisher Project

ENGINEERING AND CONSTRUCTION WORKS AND SERVICES

Construction of these facilities offers opportunities to supply materials, provide construction and engineering services over some scopes and joint venture opportunities for bigger scopes. There are services that will require joint ventures with global, experienced companies. This therefore calls for collaboration in the bidding processes in order to present technically acceptable bids.

Some of the engineering works and services to be undertaken include:

- Technical surveys
- Supply of electrical power and utilities
- Site preparation – including clearing and grading
- Installation and operation of concrete batch plants
- Supply of cement, aggregates, mixer trucks and dump trucks as well as their operation.
- Civil works – including designing, piling, excavation and backfill, foundation works, road construction
- Set-up of construction camps and the associated facilities
- Construction of buildings and housing – including the supply and construction of warehouses, administration buildings, etc.
- Electrical & instrumentation works– including designing, equipment, instrumentation and cable installation, testing and commissioning
- Telecommunication works – including the design, installation and integration of systems
- Engineering and construction equipment rentals
- Laboratory testing (soils, compaction, concrete, compression)
- Scaffolding & painting services
- Water well services
- Facilities fencing, design and construction
- Specialist pipe cleaning and flushing
- Steel bars works
- Pipe spools and structures fabrication and installation
- Welding services including weld inspection

STANDARDS AND CERTIFICATIONS

The Oil and Gas sector is highly specialized with strict adherence to standards and certifications. As such, most of the suppliers and works must meet the required industry standards. A number of institutes, such as the Ugandan Petroleum Institute at Kigumba have also been set up for the certification of welders in Uganda to be able to participate in the oil and gas activities.

The Petroleum Authority of Uganda ensures that the industry utilizes the Ugandan Standards as much as is possible so that Ugandan companies are considered in the provision of various

services. However, we should appreciate that a lot of the services have not been existent in Uganda (eg pipeline heat-tracing, welding of pipelines, drilling mud, cement for buoyancy control, among others).

Therefore, industry standards which are new for Uganda have been shared with the UNBS for adoption. This is to ensure that Ugandan companies can easily comply with the industry requirements. Some of the key standards that have been published by UNBS include those for cement, steel, cables, civil works subcontractors, sand and aggregate, among others.

EQUIPMENT AND MATERIALS

Some of the materials required for construction and engineering for the projects include the following:

Materials for civil construction include: sand, aggregates, cement for construction, steel reinforcement, gravel, granular murram, crush stone, road sub-base and base, bitumen dressing, concrete block, waterproof rolls, structural steel, fence and gate.

Mechanical equipment includes: diesel generators, pumps, welding equipment, pipes, valves, overhead cranes, storage tanks (for firewater, potable water, hot water, crude oil, diesel), hydro-pneumatic tanks, sewage-regulating insulation material, manual instrumentation (ie, pressure and temperature gauges).

Electrical equipment/material includes: earthing, various cables and conduits, sockets and switches, lighting equipment, underground cable warning, transformers and associated switchgear.

Fire fighting equipment/material includes: safety signs, boards, fire water pumps and piping, fire foam monitors, heat and smoke detectors, deluge systems.

Piping equipment includes: PE pipes, PPR pipes, PE T-joints, PE elbows, PE reducers, PPR elbows, PPR reducers, taps, washbasin, showers, bathtubs, mop pools, sinks, pedestal pans, urinals, floor drains, S-traps, cleanouts, Closet Pan, squat pans, UPVC pipes.

EMPLOYMENT OPPORTUNITIES

The oil and gas projects are further expected to create an estimated 14,000 direct jobs, 42,000 indirect jobs and about 100,000 indirect jobs. The largest percentage of the jobs will be technical. Below is a breakdown of some of the disciplines and their estimated labour requirements.

Level 4 Engineers & Managers (6%)	Level 3 Technicians (17%)	Level 2 Trades & Craft (38%)	Level 1 Basic Skills & Entry Level (39%)
Civil/Structural Engineering (340)	Mechanical Technician (722)	Civil/Structural Engineering (3,112)	Civil/Structural Engineering & related Labourers (3,902)
Mechanical Engineering (152)	Instrumentation Technician (465)	Driving (1,810)	Hospitality & Catering (1,071)
Control Centre Operations (121)	Logistics & Supply Chain Management (314)	Welding (1,230)	Security (915)
Geotechnical Engineering (112)	Electrical Technician (280)	Scaffolding (701)	Drilling Rig & related Labourers (645)
Maintenance Engineering (103)	Drilling Rig Operator/ Technician (187)	Mechanical Technician and related trades (636)	Field Production (280)

Occupational areas with the highest number of predicted jobs by qualification level (Source: Workforce Skills Development Strategy and Plan for the Oil & Gas Sub-Sector in Uganda)

CONCLUSION: HOW TO PARTICIPATE

In Uganda, the national content and procurement regulatory requirements provide for 16 categories of goods and services ring-fenced for Ugandans. These include land surveying, crane hire, locally available construction materials, civil works and supply of locally available drilling and production materials, among others.

As opportunities continue to unfold, the engineering and construction firms are encouraged to:

1. Register on the National Supplier Database (NSD) which is a pre-requisite to supply the petroleum industry.
2. Prepare, acquire the necessary certifications and build capacity through collaborations and joint ventures with experienced companies.
3. Familiarize with the required standards in the construction sector.
4. Take advantage of the various training and capacity-building initiatives such as the Skills for Construction Project and the HSE & Bid Management Training by GiZ together with the Stanbic Bank Business Incubator.
5. Individuals can register on the National Oil and Gas Talent Register (NOGTR) to enhance their visibility and chances to be considered for employment.

The Petroleum Authority of Uganda is committed to ensuring that the petroleum sector creates lasting value for society and contributes to Uganda being a sound investment destination.

Photonics and their application towards existing

Optical Technologies

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Abstract:
Light has found applications in data transmission, such as optical fibers and waveguides and in optoelectronics. It consists of a series of electromagnetic waves, with particle behavior. Photonics involves the proper use of light as a tool for the benefit of humans. It is derived from the root word "photon", which connotes the tiniest entity of light analogous to an electron in electricity. Photonics have a broad range of scientific and technological applications that are practically limitless and include medical diagnostics, organic synthesis, communications, as well as fusion energy. This will enhance the quality of life in many areas such as communications and information technology, advanced manufacturing, defense, health, medicine, and energy. In this review, we present the most common and recent applications of the fiber optic- photonic crystal based devices. These kinds of devices can be fabricated by a modification of the waveguide structures to enhance the transmission efficiency, the devices has an ultra-compact size with an overall size of the chip. Hence, such devices are useful in photonic integrated circuits for CWDM systems and future optical communication networking applications etc.

Keywords: light, photon, communications, waveguides, fibres, photonic crystals, band gap structures, photonic integrated circuits

Introduction:

The role of light is significant in our lives today. The importance of light cannot be taken for granted because it is vital to most aspects of our contemporary society. It is used everywhere whether it be building, telecommunication, transportation, entertainment, or clothing. Light has applications in data transmission, such as optical fibers and in optoelectronics. It is used in compact disc players where a laser reflecting off of a CD transforms the returning signal into music. It is also used in laser printing and digital photography. Connections between computers and telephone lines are possible with the help of light (fiberoptic cables). It is used in optical fiber lasers, optical fiber interferometers, optical fiber modulators, and sensors. Light is used in the medical field for image production used in hospitals and in lasers that are used for optometric surgery. Light consists of a series of electromagnetic waves, with particle behavior under certain circumstances [1]. Light is the range of wavelengths in the electromagnetic spectrum as shown in figure 1.

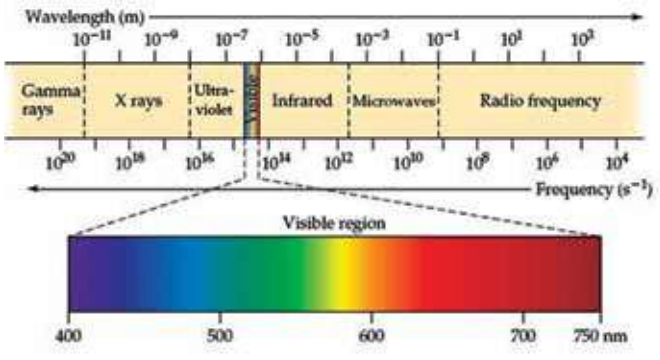

Figure 1: The electromagnetic spectrum.

Photonics is essentially the science that involves generation of a photon (light), its detection, as well as manipulation via transmission, emission, signal processing, modulation, switching, amplification, and sensing. Most importantly, photonics involves the proper use of light as a tool for the benefit of humans [2,3]. Most photonics applications, even though

they cover all technical applications over the entire electromagnetic spectrum, range from near-infrared light to visible region. The term "photonics" was derived from the root word "photon", which connotes the tiniest entity of light analogous to an electron in electricity. Just as the electronics revolutionized the 20th century, photonics is doing the same in the 21st century. Photonics is made up of many different technologies including optical fibers, lasers, detectors, quantum electronics, fibers, and materials.

Photonics is said to be an "All-Pervasive" technology because it allows unlimited light to travel faster than the electrons that are used in electronic computer chips, which means that optical computers will compute thousands of times faster than any electronic computers because of the physical limitations of electronic conduction. More wavelengths can be packed into an optical fiber to allow an increase in the transmission bandwidth that can be in conventional copper wires. There is no electromagnetic interference in light compared to electrons in copper wires.

Photonic crystals:

Controlling and streamlining the movement of light has been one of the main focus areas of research in the last few decades. Materials such as optical fibers, which operate based on the principle of total internal reflection, have significantly transformed the communication industry. The concept of photonic crystals was proposed independently by John and Yablonovitch in 1987 [4, 5]. They use the electronic band concept analogous to semiconductor crystals. Photonic crystals are dielectric materials that are periodic in 1D, 2D or 3D orthogonal directions. They can be fabricated in a simple way and have unusual optical properties.

Two-dimensional photonic crystals are the most interesting and can be categorized into two: dielectric materials in air, or air in the dielectric material. The former is fabricated easily via periodic inscription of holes in materials of high dielectric properties such as GaAs, Si, and Ge. Photonic bandgaps are characterized by photonic crystals because of the intermittent disparity in the refractive index.

Photonic band gaps have a range of frequencies that cannot allow propagating inside the crystal. Because of this peculiar property, waveguides are formed through inducing of line imperfections in photonic crystal structures. These line faults are used to guide light from one place to another. The defects are guided inside the photonic band gap through the streamline via the total internal reflection principle. Because of the asymmetrical boundary, this streamlining creates backscattering, which causes slow light phenomena. Slow light causes optical signals to compress in space, and this enables interaction between light and matter and allows miniaturization. A variety of dielectric slab materials of the high refractive index can be used to produce photonic crystal slabs. Moreover, photonic crystals based on InP/InGaAsP structure can be prepared with a slight loss.

Several types of research are on-going for the potential applications of photonic crystals. Most frequent among them are related to the photonic integrated circuits as shown in figure 2. The introduction of defects can be achieved through the photonic band gap. Instead of guiding light through total internal reflection, it could be conducted using line defects in photonic crystals. The use of a photonic bandgap to guide light allows for small bending loss even when the bending angles are large. In the area of sensors, photonic crystals have

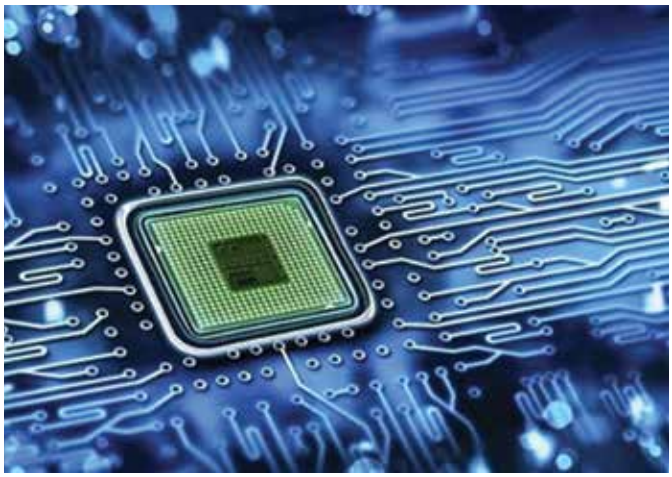

Figure 2: Photonic Integrated Circuits Photonic integrated circuits:

been widely used in the field of sensors. A photonic crystal slab provides sensitivity to the photonic band gap [6, 7]. Some of these sensors can be designed to detect pressure using a GaAs/AIGaAs slab.

Photonic integrated circuits:

Photonic integrated circuits (PICs) are optically active integrated semiconductor photonic devices. The leading commercial application of PICs are optical transceivers for data center optical networks. PICs were fabricated on III-V indium phosphide semiconductor wafer substrates were the first to achieve commercial success; PICs based on silicon wafer substrates are now also a commercialized technology.

Photonics have uses in almost every aspect of our life, ranging from daily life to highly innovative science. For instance, information processing, telecommunications, light detection, metrology, lighting, spectroscopy, photonic computing, holography, medical field (surgery, vision correction, health monitoring and endoscopy), fighting machinery, visual art, agriculture, laser material processing, robotics, and biophotonics. Similar to the way electronics have been used extensively since the

creation of earlier transistors of 1948, the exceptional use of photonics continuously increases. Economically significant uses of photonic devices include fiber optic telecommunications, optical data storage, displays, optical pumping of highpower lasers and laser printing [8-10]. Prospective applications of photonics are practically limitless and include medical diagnostics, organic synthesis, information, and communication, as well as fusion energy as shown in figure 3.

Key Applications for Integrated Photonics include:
Data Centre Interconnects: Data centrer continue to grow in scale as companies and institutions store and process more information in the cloud.

Analog RF Signal Applications: Using the GHz precision signal processing of photonic integrated circuits, radiofrequency (RF) signals can be manipulated with high fidelity to add or drop multiple channels of radio, spread across an ultra-broadband frequency range [11].

Sensors: Photons can also be used to detect and differentiate the optical properties of materials [12]. They can identify chemical or biochemical gases from air pollution, organic produce, and contaminants in the water.

- Telecommunication: optical down-converter to microwave, and optical fiber communications.
- Medical applications: laser surgery, poor eyesight correction, tattoo removal and surgical endoscopy.
- Manufacturing processes in industries: involves the use of laser in welding, cutting, drilling, and many surface modification techniques.
- Building and construction: smart structures, laser range finding, and laser leveling.
- Space exploration and aviation: including astronomical telescopes.

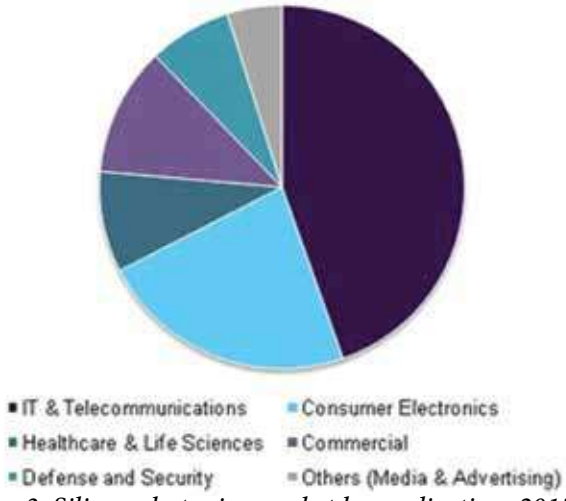

Figure 3: Silicon photonics market by application, 2015

- Military operations: command and control, IR sensors, navigation, mine laying, hunt and salvage, and discovery.
- Metrology: range finding, frequency and time measurements.
- Photonic computing: printed circuit boards, and quantum computing.
- Micro-photonics and nanophotonics.

In addition, photonic integrated circuits can remove background noise from an RF signal with unprecedented precision, which will increase the signal to noise performance and make possible new benchmarks in low power performance. Taken together, this high precision processing enables us to now pack large amounts of information into ultra-long distance radio communications.

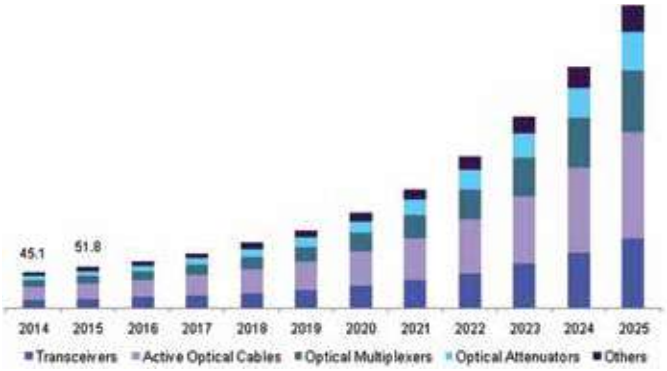

Figure 4: U.S. silicon photonics by product, 2014 - 2025 (USD Million)

They can also be used to detect abnormalities in the blood, such as low glucose levels, and measure biometrics such as pulse rate. Photonic integrated circuits are being designed as comprehensive and ubiquitous sensors with glass/silicon, and embedded via high-volume production in various mobile devices.

The global silicon photonics market size was valued at USD 123.0 million in 2015 and is expected to spectate a significant growth as photonics products would rapidly gain traction as shown in figure 4.

Conclusion:

Since the year 2000, fiber optics has provided a significant contribution in applications such as optical communications, transmission fibers used underwater, in terrestrial areas, metro and local area networks (LAN). Other special fibers have been used in amplifiers, lasers, sensors and photonics devices. Further improvements of the fiber optics can be done by providing higher bandwidth, transmissions capacities for longer distances, and introducing devices with at a lower cost. For instance, in the LAN fiber world, the use of new wideband multimode fibers is recommended

to improve the overall system efficiency. The wideband multimode fibers can be used in wider frequency ranges from visible to infrared such as the short wavelength-division multiplexing ranges 850 to 950 nm. Another rapidly growing technology is freespace communication, where the optical signals can be used for satellite–satellite communications. Recently, optical fibers have been used for transmission from light emitting sources such as high-power lasers, where the sudden changes in wavelength can be controlled easily in these devices. Hence, such devices are useful in photonic integrated circuits for CWDM systems and future optical communication networking applications etc.

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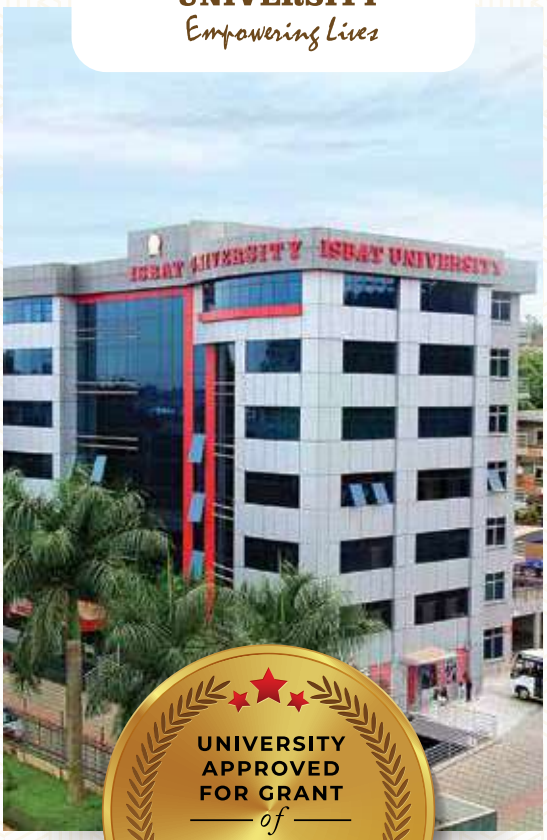

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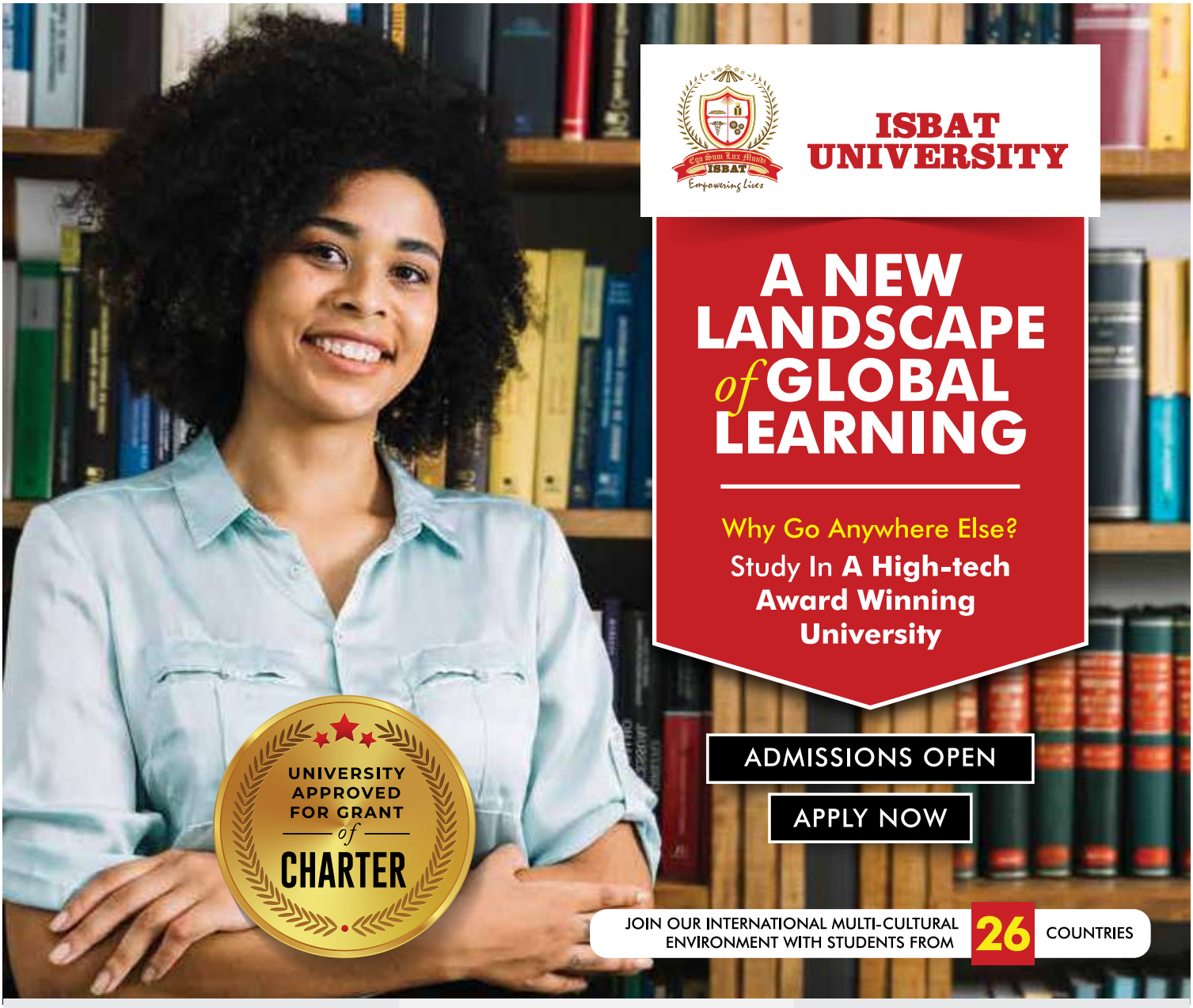

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Overview on nuclear energy reactor safety and the key issues for Uganda

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Abstract

There is a growing African interest in nuclear power. Uganda is no exception. South Africa, which already has a nuclear power plant, has been considering expanding its capacity. The role electricity plays in our lives by enhancing our productivity, comfort, safety, health, and economy is obvious. Nuclear-generated electricity is unique, in that it inherently addresses many of the shortcomings of the other means of power generation. The use of nuclear power provides answers to many problems in the areas of environment, safety, economics, reliability, sustainability, and even waste. Hence, it enhances economic competitiveness, development and energy security. There are many new designs of nuclear reactors based on the coated fuel particles. Among them is the Generation IV reactors category which has a bright future in the electricity and hydrogen production because of their superior characteristics. Gen-IV high temperature nuclear reactors use TRISO (tristructural isotropic) particles for containment of radioactive fission products. In these particles silicon carbide (SiC) is the main barrier for containing solid fission products (see Figure 1). Even still replacing SiC with other materials of superior properties such as zirconium carbide to further enhance irradiation, mechanical, thermal, chemical, physical properties of the diffusion barrier layer is being investigated. This paper gives insight on nuclear reactor safety and key issues for Uganda to consider in preparation for nuclear energy.

Keywords: Nuclear reactor safety; Public involvement and acceptance; Uganda preparedness

Introduction

A key feature of the modern world is the high consumption of electrical energy. Two competing factors shaping the world energy economy are the rapid industrialization of the developing countries and the global drive to reduce the carbon footprint. Industrialization leads to a corresponding growth in electricity consumption. Currently, about 85% of the world's energy consumption comes from fossil fuel (Hoffert et al., 2002; Malherbe et al., 2008). However, the Kyoto Protocol with its demand to lower the carbon footprint necessitates a movement away from traditional fossil fuel-based power plants to alternative power production methods. Due to depleting hydropower plant sites in Uganda and with global greenhouse gas emissions projected to continue to increase, there is added demand both to achieve greater energy efficiency and to pursue all measures to develop and deploy carbon free energy sources. Nuclear power is one such energy source with a low carbon footprint (Pidgeon et al., 2008).

However, the perception of the general public in most countries is negative towards it. This negativity is based on the fear of possible leakage of radioactive high level nuclear waste into the environment during long-term storage of the waste and during accident conditions such as those that occurred at Three Mile Island, Chernobyl and Fukushima (Pidgeon et al., 2008; Spence et al., 2010). It is important to note that the nuclear energy industry has a very successful safety record: only those three major accidents have occurred in over 17,000 cumulative reactor-years of commercial nuclear power operation in 33 countries in the 50-year history of civil nuclear power generation. The number of deaths altogether is reported to be less than 100 (WNA, 2019b). Therefore, the general public requires proper sensitization beforehand and the reactor safety features and operations have to be scrutinized.

Nuclear reactor safety

The safety of a reactor is of major concern to its owner for several reasons: to ensure the safety of the public, the reactor operators, and the investment itself. That means, apart from the four important factors (1) cost, (2) safety, (3) waste management, and (4) proliferation risk), any country has to see to it that, before building a nuclear power plant, the design of a reactor takes centre stage (Char & Csik, 1987; WNA, 2019b) The design and operation of a nuclear power plant maximise energy

production, lower the likelihood of accident occurrence and also prevent major human consequences when they occur. However, the reactor design has a cost implication (WNA, 2019b).

Safety is closely linked with security and safeguards. Safety focuses on unintended conditions or events leading to radiological releases from authorised activities. It relates mainly to intrinsic problems or hazards. Security focuses on the intentional misuse of nuclear or other radioactive materials by non-state elements to cause harm. It relates mainly to external threats to materials or facilities. Safeguards focus on restraining activities by states that could lead to acquisition or development of nuclear weapons. This concerns mainly materials and equipment in relation to rogue governments (Porter et al., 2013; Verfondern et al., 2007) (WNA, 2019b).

To achieve optimum nuclear safety, we need to have well-trained human resources, especially the nuclear power plant operators and national regulators. The operator is responsible for safety and the national regulator is responsible for ensuring the plant is operated safely by the licensee and that the design is approved and certified to protect people and the environment. These national regulators work hand in hand with international regulatory bodies such the International Atomic Energy Agency (IAEA). To mitigate consequences of failures, a 'defence-in-depth' approach has been adopted by some countries, where multiple safety systems supplementing the natural features of the reactor core are applied (WNA, 2019b). The main aspects of the approach include:

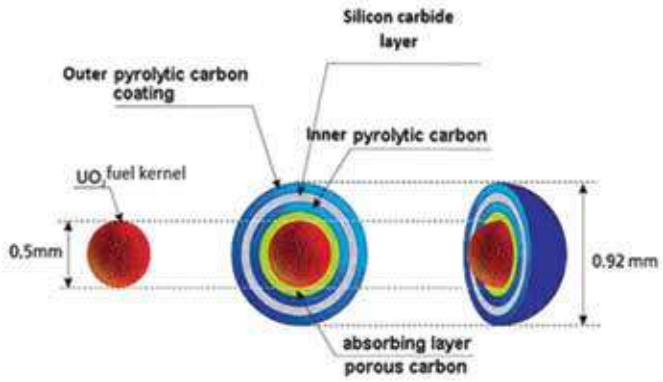

Figure 1: Illustrative cutaway drawing of the coated TRISO fuel particle. Taken from (Powers & Wirth, 2010).

- high-quality design & construction
- equipment which prevents operational disturbances or human failures and errors developing into problems
- comprehensive monitoring and regular testing to detect equipment or operator failures
- redundant and diverse systems to control damage to the fuel and prevent significant radioactive releases
- Provision to confine the effects of severe fuel damage (or any other problem) to the plant itself.

Nuclear accidents and the closing of nuclear reactors

The Chernobyl nuclear disaster of 1986 was the result of a flawed reactor design that was operated with inadequately trained personnel. The resulting steam explosion and fires released at least 5% of the radioactive reactor core into the atmosphere and downwind. Another nuclear accident (scale 7) occurred in Japan at Fukushima Daiichi on 11 March 2011. This was as a result of a major earthquake, a 15-metre tsunami disabled the power supply and cooling of three Fukushima Daiichi reactors, causing a nuclear accident (Kim et al., 2013). Even though it was triggered by tsunami, it has been reported that there was a number of technological failures derived from the failure of multiple social safeguards that lead to the overall manifestation of the nuclear accident. The multiple background defects that were embedded in the technological system included: construction of the plant in a coastal area, age of the reactor, inferior technology, many nuclear reactors in one site, insufficient earthquake-resistant safeguards, etc. (Funabashi, 2012).

Even though China and Russia have since expanded their nuclear industry capacity, the Chernobyl and the Fukushima nuclear accidents have significantly affected the overall nuclear energy industry. The public attitude toward nuclear energy has significantly changed: it has lowered the public acceptance to nuclear energy and increased costs. Public acceptance of nuclear energy is highly correlated with a government's political decision-making (Kim et al., 2013). For example, Germany planned to decommission the last nuclear plant by 2022 and its coal-fired power plant by 2038. The anti-nuclear movement has a much longer tradition in Germany, dating back to the country's Green Movement in the 1970s. The rejection of nuclear power remains strong despite the technology's much smaller carbon footprint. The pressures from the public calling for the closing of nuclear plants become even more intense after the Fukushima nuclear accident of 2011 (Schneider et al., 2019).

In the USA, there are currently 96 commercial nuclear power reactors licensed to operate. However, a number of them are permanently closing. Nuclear power is economically facing stiff competition in an electricity market from other alternatives such as natural gas, wind and solar power (renewable energy sources). The age of the existing nuclear reactors amidst unpredictable acci-

dents, it requires that more costly inspections, maintenance, repairs and generic backfits. This has hiked the running costs up and forced more reactors into permanent closure (Schneider et al., 2019). For instance, the TVA nuclear power plant in the US (in Figure 2) was delayed after the Fukushima disaster in 2011 in order to comply with a new host of safety regulations. This was the first reactor to meet the new Fukushima-related safety orders issued by the NRC which further escalated the construction costs (Schneider etal., 2019).

Figure 2: The TVA nuclear power plant in the US

Uganda's preparation for nuclear energy

The Uganda Nuclear Power Roadmap Development Strategy was approved by the cabinet in April 2015. It is reported that Uganda plans to have a running nuclear power plant by 2031 (WNA, 2019a). To mitigate harmful nuclear effects, the Government should enhance transparency of the decision-making process by implementing participative programmes where policy-makers, stakeholders, and representatives of the local communities can jointly discuss energy production schemes. The participative approach will allow the country to make informed decisions about its energy mix including the risks and opportunities involved. The Government has to identify the fundamental issues that affect public acceptance of nuclear energy. The Government should also consider its technological, industrial, economic and safety status in relation to nuclear energy, this will help in establishing a better national policy. It is therefore, very important for all the stakeholders to be involved as the Government attempts to address the preliminary key issues here listed, among others:

- Does Uganda need a nuclear power plant?
- Have other alternative energy sources been exhausted?
- What capacity does Uganda need for the current and future needs?
- Where will the nuclear power plant be located (land, compensations and safety)?
- How prepared is Uganda to embark on the nuclear power plant project (human resource, security, public sensitisation)?
- What are the other things that could cut costs (uranium mining and Uganda producing her own yellow cake, etc.)?
- Which type of nuclear plant does Uganda plan to have?
- How much will it cost?
- Where will Uganda get the money from?
- How much will Uganda need to contribute?
- How much will Uganda need to borrow from the bank or other bodies? At what interest rate and what will be the repayment terms?
- Will the Uganda income be sufficient to cover not only the monthly capital repayments and interest, but also on-going maintenance and running costs?
- How will the down-payment and monthly repayments affect our other plans?

The last but important question should be: is the debt bearable? (That is, the debt as a result of the nuclear power plant plus other on-going and planned debts of the country).

Summary

- The green future and modern world characterised by the high consumption of electrical energy needs nuclear power (i.e. huge amount of energy are generated from a very tiny source with very low carbon footprint).
- The nuclear energy industry has a very successful safety record: In about 33 countries operating commercial nuclear power, only 3 major accidents have occurred in over 50-year history of civil nuclear power generation.
- The nuclear reactor safety and security is majorly enhanced technologically with appropriate human resource. This calls for huge investments that may sometimes become unbearable.
- Public participation is important in the nuclear industry; it improves public acceptance and allows the governments to make informed decisions.

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Force Account (FA) Modality as Implementation Strategy for Road & Bridge Works

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ABSTRACT:
This paper discusses Force Account as a strategy for implementation of road and bridge works. It further gives progress in terms of projects undertaken by the Ministry, the benefits and challenges of force account. The paper also provides a proposed criteria for selection of projects to be implemented by force account.

Introduction
The PPDA Act of 2003, the law under which procurement activities in Uganda are governed, defines Force Account (FA) as undertaking the works of a procuring organization using own personnel and equipment or of another procuring organization. It is noncompetitive bid contract where an authorized entity has to complete the project by furnishing the labour, equipment, and materials under its direct control.

Over the years, there has been deterioration of the state of district roads due to inadequate maintenance. As a result government set up Uganda Road Fund URF in 2009 charged with financing the routine and periodic maintenance of public roads which has relatively improved the situation.

Given the poor condition of district and community access roads, government further in 2012 re-introduced Force Account as a policy and modality for maintenance of roads using funds from URF. Force Account has widely been adopted by government agencies in implementing road works particularly rehabilitation and maintenance. The policy shift was cemented by acquisition of road construction equipment from China in 2012 and from Japan in 2017.

After the acquisition of the road equipment from the People's Republic of China in 2012, the Ministry of Works and Transport (MoWT) established District Road Rehabilitation Units (DRRU) in four regions of the country i.e. Central, Northern, Eastern and Western to undertake rehabilitation of district roads, Urban Roads Sealing Units to seal urban roads. The Ministry also established a bridge construction unit. Now all local governments and some central government agencies maintain roads by force account.

Since the re-introduction of force account, there has been significant progress in improvement of accessibility to markets, health centres, schools and to trunk roads. This paper will focus on District Road Rehabilitation projects and bridges done by force account.

The Ministry in particular has successfully implemented a number of projects by force account in different parts of the Country.

The objectives of this paper therefore are to:-

a) Discuss progress on selected projects;
b) Share the lessons learnt from implemented projects;
c) Highlight the benefits and challenges of Force Account modality of project implementation; and
d) Propose a criteria and thresholds for selection of projects to be implemented by Force Account.

Progress of Works by MoWT
The MoWT has implemented a number of projects by force account in the different regions of the country. The figure below gives the progress per region per FY.

Fig.1, shows that there is significant increase in the number of km rehabilitated annually from the FY 17/18 & 18/19. This is attributed to arrival of new high quality equipment from Japan in 2017 and increased funding to the project.

Table 1. Bridges and drainages structures Project implementation by FA

Project	Location
Reclamation of 25.1Acres	Namanve
Construction of a river channel	Namanve
Okokor Bridge	Kumi
Completion of Kaguta bridge	Lira
Agwa Bailey Bridge	Lira

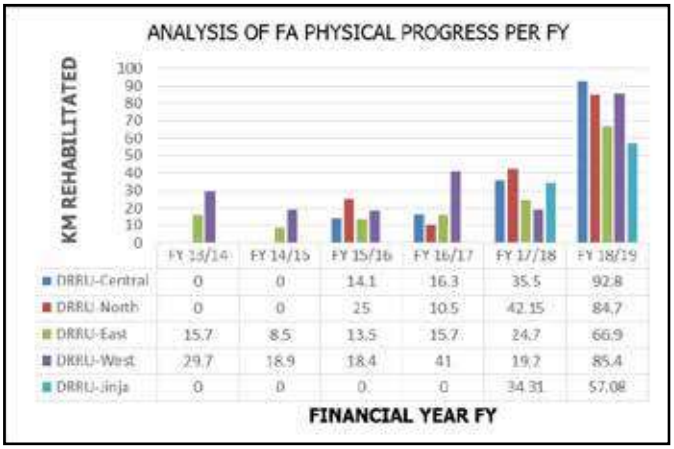

Figure 1: Progress of DRRU

Figure 2: Accessibility for school going children improved-Simple solution but Vital (Lwengo) FY 2018/19.

Figure 3 Reclamation of 25.1 acres of swamp land in na-manve FY 2016/17

Musizi Swamp crossing	Kibaale
Kabuhuna swamp Crossing	Kibaale
Saaka Swamp Crossing	Kaliro
Kangai Swamp Crossing	Dokolo

Lessons learnt

Many lessons have been learnt when implementing works by force account modality however; only three have been discussed in this paper and include;

Technical expertise;

A person implementing works by force account must understand the job. The engineer must know the most appropriate and workable methods to be used to execute works. This involves understanding the Job task complexity. The dimensions of task complexity are unfamiliarity, complicatedness and objective complexity as grouped by (Gill, 2010). Unfamiliarity means absence of task specific knowledge hence uncertainty or difficulty of performing the task while complicatedness deals with the challenge of finding or describing a path from

Figure 4: Okokor Bridge in Kumi

one stage of work to another. On the other hand, objective complexity considers interrelationships between tasks and their dynamics like small changes can have big impacts. It is objective because it's a function of the task state, rather than being a function of the task performer's state of mind.

Bridge construction works are seen as complicated by many practitioners because of the tasks involved and the interrelationships between tasks. During a joint monitoring of infrastructure projects by budget monitoring and accountability unit BMAU 2017/18, Okokor Bridge in Kumi was inspected. The monitoring team was in disbelief that the bridge was constructed by Force Account modality because the works were of a high quality.

Stewardship

Stewardship involves having interests beyond purely economic motivations and these non-economic motivations can cause one (Force Account Manager) to pursue cooperative, pro-organizational behaviors in performing his/her duties in providing service to others. People entrusted to implement projects by force account need to work as stewards.

According to Caldwell & Karri (2005), stewards hold higher order needs, they are intrinsically motivated and will actively seek opportunities for personal growth and achievement. These motives will direct them to work harder on behalf of the organization. In terms of use of power, stewards are assumed to prefer personal power (i.e. expert power – power based on knowledge) as opposed to managerial and political power. Force Account Managers need to possess values like trust, selflessness and convergent interest. Trust is one very important ethical stewardship value that cannot be ignored when using force account modality. Indeed management relies on trust that the Force Account Manager will undertake the works once resources are released to him or her. While it is difficult to quantify trust amongst employees, Force Account Managers have to demonstrate trust in the way in which they manage resources in their own control to produce high quality work.

Managing the desire to use FA resources for personal benefit rather than for executing works for the greater good of society is critical and central in delivering projects implemented by force account.

Managing documentation and work

In the past auditors would focus on the physical work done and not the quality of documentation. Today the reverse is true the auditors focus on the quality of paper work and less attention to the physical work while the population focuses on the physical work. The force account managers therefore have to produce both quality work and quality documentation.

Benefits and Challenges of FA

4.1 Benefits of FA

Since the reintroduction of Force Account in 2012, the following benefits accrued;

Improved rural accessibility through timely maintenance of district roads and bridges; timely interventions to bottlenecks in connectivity; improved quality of district and community access roads; capacity building through operator training. Further many engineers have gotten hands on experience; efficiency gains where the entity is able to execute works much faster, enhancement of internal capacity of the procuring entity since works are executed and supervised by the procuring entity staff and cost of supervising consultants savings compared to other methods. Currently the average cost for rehabilitation of a district road to gravel standard by force account is 30milion per km. With force account emergency works can easily be undertaken compared to other procurement methods.

The control of quality is in the hands of the employer rather than the contractor and consultant.

Challenges of FA

There is a risk of producing low quality work if the implementing engineer is not a braced with the nature of works, task procedures and methods; delayed release of funds-this leads to stoppage of works and thus affects the logical flow of activities; Justifying cost over runs in force account is more difficult than in contracting; Resources like fuel can easily be consumed without tangible work outputs. Force account model exposes the government to the greatest degree of risk, since it cannot pass risk on to any other entity besides itself (Satyanarayana, 2012).

Huge volume of paper work to explain the utilization of resources inform of work orders, requisitions for inputs like fuel, local materials coupled with detailed reporting and accountabilities. There is no established procedure for selection of projects to be implemented by force account modality.

Criteria for selection of projects to be implemented by Force Account

While the guidelines for implementation of works by force account are available, there is no established criteria for deciding which project can be implemented by force account. The procurement entity can use the criteria proposed below for selection of projects to be implemented by force account modality.

Table 1. Proposed Project Selection Criteria

Project Aspect	Rating
Complexity (scope)	Moderate
Size (scope)	Moderate
Urgency	High
Financial Value	Moderate
In house expertise	High

The rationalization of projects by value and size is based on the experience of the writer in implementing force account projects.

Table 2. Proposed thresholds for Force Account Works.

Project Type	Threshold Ushs. Bn
Bridges	0-10
Roads (Gravel)	0-5
Roads (Bitumen)	0-10
Building works & renovations	0-2
Swamp crossings & reclamation	0-15
Ferry Landing sites	0-5

Source: Drawn from implemented projects

Projects of higher value be implemented by contracting

CONCLUSION

Force Account is a good strategy for implementation of works of low and moderate value. It's also very good method for handling emergency works that do not need time for procurement. With FA rural accessibility has improved and it has increased and communities are now able to access goods and services.

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Journal Article

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Eng Samson Ttondo Ssemakula holds a Master of Science in Power Systems Engineering [FROM WHICH UNIVERSITY?] and a BSc in Electrical Engineering from Makerere University. He has seven years' experience in power systems engineering with major expertise in power systems distribution. He has experience in power distribution network design and construction, network component maintenance, the management of faulty systems, power quality and reliability analysis, and solving customers' engineering issues. Samson works with UMEME as a customer service engineer. He also works as a consultant on energy efficiency programmes, helping customers utilize power more efficiently. Samson also works as a researcher on power and energy projects.

Eng Juliet Pauline Apio holds a Bachelor of Science in Mechanical Engineering from Makerere University. Furthermore, Eng Apio has a certificate from the Planner Academy of Johannesburg in South Africa. Juliet has over nine years of professional experience in the following areas: (1) the design, operation and maintenance of plant and machinery, (2) the practical development and implementation of strategy in asset care, (3) the key principles used in asset management, (4) the knowledge to refocus and undertake reforms in plant maintenance approaches, (5) carrying out asset audits, and (6) handling projects in a controlled environment (Prince 2). Currently Eng Apio is a projects and maintenance engineer at Total Uganda.

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Eng. Francis Okello, holds a MSc Degree in Civil Engineering from Makerere University and an MBA degree from the University of South Wales. Francis has over 15 years' experience in the Water and Sanitation Sector and has worked in a number of countries including Uganda, Liberia, Sudan, Somalia and Ethiopia. Currently as the Senior Program Engineer, with Engineers Without Borders - USA, he leads the design and installation of Solar Powered Water Systems in selected refugee settlements and host communities in Uganda. Relatedly, he also coordinates the Solar Technical Working Group tasked to prepare an annex to the Water Supply Design Manual of Uganda.

Eng. Wilfred Kaweesa holds a BSc (Hons) in Electrical Engineering from Makerere University. With extensive experience in the electricity distribution sector, his specific areas of expertise are MV network planning, design, overhead power line construction, power systems protection and coordination and control, transformer and switchgear maintenance, and generator repair and installation. Currently, Wilfred works with Uganda's largest electricity distribution company UMEME as a Customer Service engineer for the Northern Region. In his role, he is responsible for all network operations and the systematic management of all engineering resources, people, materials and processes within the region. Tel: +256-784852959, Email: wilfred.kaweesa@gmail.com

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Eng Innocent Godwins Owino holds a Bachelor of Science in Civil Engineering of Makerere University. He has over 10 years' civil engineering experience from various capacities in construction supervision and management of large scale donor funded projects such as high voltage transmission lines and associated substations. He has experience in civil and structural construction designs, formulation of technical specification, tender document preparation and evaluation process of different financing agencies related to EPC contracts. He has vast knowledge in handling construction claims and contracts administration using FIDIC contracts. Currently works with the Uganda Electricity Transmission Company Limited as projects engineer in a number of engineering roles and has been appointed the contracts manager of one of the ongoing EPC Projects.

Eng Aloysius Nabucha holds an MSc in Civil Engineering of Makerere University, and a Bachelor of Engineering in Civil and Building Engineering (First Class Honours) of Kyambogo University, Uganda. He is a registered engineer with the Uganda Engineer's Registration Board (ERB 1147) and a registered corporate member of the Uganda Institution of Professional Engineers (UIPE 1237). Currently serving as a senior engineer (Civil), he has also acted as a district engineer for 10 years in Budaka District Local Government. He has served with a number of organization and firms and has great experience of more than 20 years in engineering design, construction supervision and contract management of engineering projects including: road construction projects, building construction projects, piped water systems, and gravity flow water systems, among others.

Eng. Daniel Mufumba holds a Masters of Science in Construction Management from Makerere University, Post Graduate Diploma in Construction Project Management – Makerere University and Bachelor of Science degree in Civil Engineering from Kyambogo University. He is currently the Vice Chairman UIPE- Jinja Branch. Daniel is Specialized in the Design and Management of Construction Projects including Roads, Building structures, Water and Sanitation Engineering, as well as Runways, Taxiways and Aprons for International Airports.

Eng Edward Baleke Ssekulima holds MSc Electrical Power Engineering (First Class), MSc Renewable Energy (CGPA 5 /5), BSc Electrical Engineering (First Class), Postgraduate Diploma in Project Planning and Management (First Class), Certified Energy Auditor (CEA) Eng Edward Baleke Ssekulima was the project coordinator for the 183 MW Isimba Hydropower Project under the Ministry of Energy and Mineral Development. He was involved in project development right from the feasibility studies in 2011. The key tasks undertaken included contract management and supervision of the Engineering, Procurement and Construction (EPC) project works. He further served as the deputy secretary to the Karuma and Isimba Hydropower Projects Steering Committee which is the top supervising organ of the Government's two flagship power-generation projects of Karuma and Isimba.

The above are some of the lucky engineers who were registered in 2019, the 50th year of ERB, and who gave us a chance to publish their profiles.

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41	1165	Eng Mulolo Francis	Civil
42	1166	Eng Ssebutemba Shakibu	Civil
43	1167	Eng Ngobi Herbert Muzaale	Civil
44	1168	Eng Ngonzebwa Racheal	Civil
45	1169	Eng Mwesige Godfrey (Dr.)	Civil

46	1170	Eng Kizito Nathan Musisi	Civil
47	1171	Eng Gombya Ivan	Civil
48	1172	Eng Keesiga Diana	Civil
49	1173	Eng Anguyo Davis Madaraka	Civil
50	1174	Eng Migadde Johnmary	Electrical
51	1175	Eng Masereka Enos Bright	Electrical
52	1176	Eng Okello Francis	Civil
53	1177	Eng Baireghaka Benedicto	Civil
54	1178	Eng Kalyesubula John	Electrical
55	1179	Eng Ambazimana Andrew	Civil
56	1180	Eng Nattabi Irene	Telecommunication
57	1181	Eng Owino Innocent Godwins	Civil
58	1182	Eng Kalanzi Richard	Mechanical
59	1183	Eng Yebazamukama Collins	Civil
60	1184	Eng Ssekulima Edward Baleke	Electrical
61	1185	Eng Kaheeru Fredi	Civil
62	1186	Eng Ekukut Yokosofaty	Civil
63	1187	Eng Kiwanuka Samuel	Civil
64	1188	Eng Namukasa Joan Kamya	Mechanical
65	1189	Eng Apio Juliet Pauline	Mechanical
66	1190	Eng Kiboigo Nelson Junior	Electrical
67	1191	Eng Mugisa Stephen	Electrical
68	1192	Eng Agaba Rugaba Nicholas	Civil
69	1193	Eng Ojara Allan Bruce	Civil
70	1194	Eng Opuch Chris	Civil
71	1195	Eng Mutegeki Godwin Geoffrey	Civil
72	1196	Eng Kabazira Ireen	Civil
73	1197	Eng Mutumba Daniel	Civil
74	1198	Eng Batenda Felix	Civil
75	1199	Eng Kajwalo Nancy	Civil
76	1200	Eng Lukala Justine	Civil
77	1201	Eng Turyamureeba Perezi	Civil
78	1202	Eng Kafeero Frederick Ssali	Electrical
79	1203	Eng Ssemakalu Ttondo Samson	Electrical
80	1204	Eng Nanyombi Barbara	Civil
81	1205	Eng. Kaweesa Wilfred	Electrical
82	1206	Eng. Odongo Mark Ajal	Electrical
83	1207	Eng. Ssegawa Dennis Williams	Civil
84	1208	Eng. Mugizi Herbert Magyezi	Mechanical
85	1209	Eng. Wasukira James Waniala	Mechanical
86	1210	Eng. Byaruhanga Atwooki Deo	Mechanical
87	1211	Eng. Kaddu Kenneth	Electrical

Laugh and Sleep it off

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It is again a Monday. It is my custom to spend all Mondays in bed. I don't like Mondays because none of my missions has ever succeeded on Mondays. Today's Monday is a special one and I am in a fix.

I have to get up at 5:30 am as I am one of the candidates who are to sit an interview for the post of Chief Engineer at the headquarters of UPEMCO Uganda Ltd this morning.

At 9:00 am, I and other 15 candidates are seated on a single bench at UPEMCO offices looking eagerly at the office door with the inscription "INTERVIEWS IN PROGRESS".

All are waiting for their turns to be called in for the interviews. Suddenly, the door opens and a secretary calls my name "Mr Kamunye". Sweating, I hurriedly stand up, adjust my hired suit and enter the room.

"In all your documents, the only relevant academic document is the PLE transcript. These new generator sets are prime moved by gas fueled engines, and they can only be operated by the engineering degree holder. The sets are very complicated. Didn't the advert read that this post is for a degree holder in engineering? One bald-headed man who was seated in an armless chair at the edge of the table, asked.

"I don't have a degree, but I have I have the technical knowhow and experience in operating and repairing the gas turbines, electricity–gas converters, gas-fired power generating sets similar to your brands. I worked in a power generation plant in Botswana for six years," I replied in my broken English. The interviewing murmurs.

"Do you know English?" one old lady with gold-framed spectacles, asks.

"English for what? Electricity has no language....the users aren't interested to know that the electricity supplied is generated by machines operated by the engineer who is eloquent in *English*, or R*unyankore, or...,* I am only fluent in *Luganda,"* I replied.

On hearing this, the chairperson gave me my PLE transcript and one young man in a blue suit held my hand and led me outside with a piece of advice. "We have been impressed by your smartness and your determination, Mr Kamunye; but this job is for a degree holder. This country needs young determined men like you and I believe you will soon get a job elsewhere," he says.

I get confused. Truly speaking I wanted this job. One month's salary could have solved my two years' problems. As I descend the stairs, I curse the interviewers for the *"nnugu"* they had over me.

Why wasn't I asked to produce a degree when I was called to rescue *MV Kaawa* from sinking when she collided with *MV Kabaleega?* I assembled and tested all machines which are to be used in drilling oil in Hoima; the *bazungu* neither asked for a degree nor English fluency: *W*hat is the secret behind these people's motive? I have to investigate. I must see the Inspector General of Government to reprimand these culprits. It comes to my mind that this is Monday and as earlier said, all Mondays are a menace to me.

As I walk along one crowded and potholed Kampala Street, one muscular man in early fourties taps my shoulder.

"Why are you talking to yourself young man?" he asked me and seemed to be affable.

"I have been denied a job because I don't have a certificate," I reply.

"Do you want a certificate?"

"I want a job."

"I know, but how will you get a job without a certificate? Do you think at your age you can go to the university, learn for four years and get a degree?"

"No."

"Okay, follow me. My name is Nkwenge. Yours?"

"Kamunye."

We took a *boda-boda* ride to a certain restaurant-cum-bar. At the corner table, we met a very smart man in a dark business suit, wearing a number of rings on his fingers, and chains over his immaculate suit, all in gold. Before him on the table stood a glass of juice as he read a glossy thick magazine, *The African Woman.* After exchanging greetings, "my friend" introduced me to this man.

"Prof Kafuru, meet my friend Kamunye, he wants a degree," Nkwenge said.

Kafuru drew a big briefcase which was on the floor from under a table and opened it.

"What degree and which university – Makerere, Mbarara, Nkumba, Nairobi, ...?"

"Make one of Oxford that they give him full respect," Nkwenge interrupted, and "Prof Kafuru" laughed.

As Kafuru laughed, I saw that he had a pair of gold teeth, scattering light reflections in the restaurant. He started sorting items in his big briefcase and I took a glimpse of what was in the briefcase. I saw many passports of different nations and ministries, and stamps of all kinds. Oh yes, the State House seal was there too! *Allah akbar!* I could see different countries' national identity cards, work permits, visas, etc.

"No Oxford degree here. I have one of Cambridge, but give me one hour," Kafuru says as he presses some numbers on his expensive Iphone handset. "*Eno ye Kampala*, young

man. Do you have two million?" Kafuru demands.

Hardly had I started answering him than he started talking to someone through his phone. "Hello Zed, *njagala baluwa ya* Engineering... no no no. Not of Makerere, *ezo baazikoowa dda buli Munnayuganda agirina.* I want one from Oxford ....er .... Don't mind, I have the seals, stamps and sample signatures here..., yes of 1998...., yeah, that time the colour was blue and green..., yes, yes... hurry up my customer wants to graduate today here in a bar!" he said.

Dear readers the whole process ended at 06:00 pm at a cost of Sh900,000. I left to my *muzigo* at Bwaise as "Maxwell Kitooke," a holder of a first-class degree – a "BSc in Electrical Engineering of Oxford University".

Later that evening, I decided to refresh my mind by a cold Bell at a certain k*afunda* as I watched TV, since I don't have one at home. Our local television programmes on NTV, UBC, NBS and *Telefayina* are the same yesterday, today and possibly tomorrow. "The Bududa landslide victims have refused beans supplied by WFP; they want beef. The Opposition Coalition has decided to front an old time politician Ken Lukyamuzi to contest for President of the Republic of Uganda in the 2021 General Election. One of the newly acquired Uganda Airlines aircrafts, a Canadian made Bombardier ...." *The programme is interrupted by special announcement!*

"The spokesman of UPEMCO Uganda, announces that the interview exercise for the post of Chief Engineer resumes tomorrow at 9:00am after the failure to get a right candidate with the required qualifications today. All Ugandans with required qualifications are requested to...."

Next day on Tuesday, I got prepared very early and at 9:00 am I was at the same office. I was on Monday, with a different hired suit, sunglasses, and trimmed beards but with my acquired new name, Maxwell Kitooke.

I was called inside for the interviews.

The panel members admired my "degree". They spent half an hour passing it to every member to see and feel it. Finally the chairman stood up. We shook hands. This reminds me of the legendary sports song of 2012 in Sri-Lanka *"Stand up for the Champion."*

"On behalf of the members of this Committee, we congratulate you. We are happy to see that our Ugandan son studied at Oxford and acquired a first-class degree in Electrical Engineering. We are indeed impressed by the way you kept your certificate for over two decades spotless. We are now very contented that you shall keep our machines immaculately for lasting life. Congratulations, you have won the job and please prepare to start working immediately!"

As you read this, I am the Chief Engineer of UPEMCO Uganda Ltd. My office is on Floor 6, Room No. 42. You all agree with me that there is no load-shedding anymore. That is the work of Prof. Kafuru and his friend Nkwenge.

Currently nobody comes to my Office to complain about electricity load shedding, but I feel lonely in the Office. Kindly visit me that we can share what is transpiring between Arsenal and Manchester United. ©

Hydraulic Road Binders (HRBS), the future of road-soil stabilizaton in Uganda

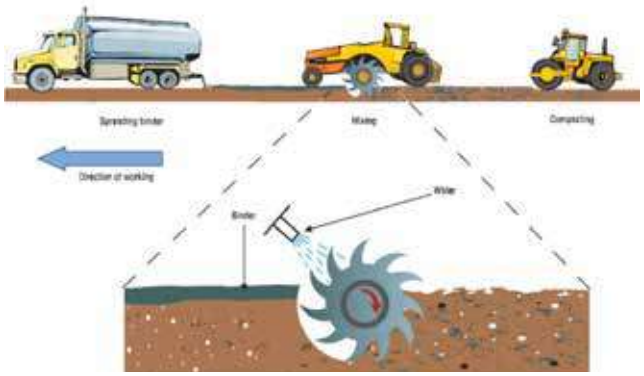
Whenever the soil available for construction has unsuitable properties, the engineer has to choose from one of the three options; i.e;

- Modify the design to suit the material,
- Replace the soil with suitable material,
- Upgrade the properties of the insitu/available material.

The latter is known as Stabilization, and can be achieved mechanically by changing material's gradation or chemically through treatment with hydraulic road binders. Soil treatment with hydraulic road binders offers pavements engineers an alternative to the traditional strategies utilized (remove "bad soil" and replace with new aggregate). The process not only offers the ability to enhance the engineering characteristics of an unsuitable soil, but also offers the engineer a more sustainable and cost effective approach to pavement construction. HRBs are also formulated to reduce the Plasticity of most clay soils unlike ordinary Portland Cements.

RoadCem is Uganda's first Hydraulic Road Binder (HRB) produced by Hima Cement Limited. **RoadCem** is effective in stabilizing a wide range of soils including granular materials, silts and light clays. It is a well-engineered blend of lime, cement, fly ash, GGBS and other carefully selected pozzolanas manufactured in conformance to the Uganda HRB standard (US 371) in accordance with (EN 196) and its usage is provided for, in most engineering design manuals. It is also engineered using LafargeHolcim's sustainable binder technology, to perform on a wide range of soils while offering reduced embodied carbon in comparison to traditional cement stabilization.

A dosage of 3% to 6% with **RoadCem** is always sufficient to stabilize the pavement layer. This is so low compared to the amount of Crushed stone (CRR) that would be needed to stabilize the same pavement layer. The total cost of materials with **RoadCem** stabilization is thus cheaper. The reduced need for aggregates also leads to a huge cost saving on material



haulage, fuel and machinery - fleet. In addition to this, **RoadCem** offers from Hima Cement come with subsidized; binder-spreading, logistics and storage offers. This further saves the project on machinery-fleet requirements.

In-situ Materials can be stabilized with **RoadCem** and re used saving time and money. Crushed stone base layers can also be replaced or partially replaced with stabilized gravel layers. This partially saves the environment from the effects blasting rocks for aggregates. With the ever increasing shortage of good quality construction materials on most road projects coupled with, the need to build more reliable and environmentally friendly roads, **RoadCem** remains the ultimate solution to Road Soil Stabilization.

Come test **RoadCem's** performance yourself for your next project.

The other innovative products from Hima Cement Ltd include PowerPlus 42.5R the CEM I OPC, Power Max 42.5N the CEM II, MineCem 42.5 the sulphate resistant CEM III, RapidSet 42.5R for precast, MultiPurpose 32.5N CEM IV, PowerCrete the first 52.5N, and SupaSet 32.5R the CEM II.

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Congratulations

ENGINEERS REGISTRATION BOARD (ERB)

ON YOUR 50TH ANNIVERSARY

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