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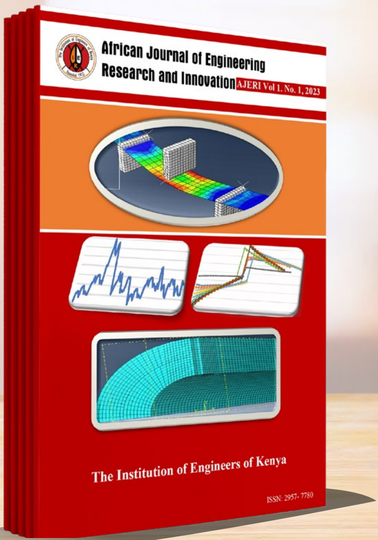

AJERI

African Journal of Engineering Research and Innovation (AJERI) Scientific Conference

Theme: Engineering for Transformation
Date: 24th–25th July 2025
Venue: Kenyatta University Nairobi, Kenya

The Institution of Engineers of Kenya (IEK), in partnership with the Engineers Board of Kenya (EBK) and Kenyatta University (KU), is pleased to announce the upcoming AJERI Scientific Conference, which will take place at **Kenyatta University,** Nairobi, from **24th to 25th July 2025.**

This landmark event will focus on Engineering for Transformation, bringing together engineers, researchers, innovators, and stakeholders from Kenya and beyond to engage in knowledge sharing and dialogue on transformative engineering solutions.

CONFERENCE REGISTRATION

Physical Attendance:

Member: Kes 20,000 | Non-Member: Kes 25,000 | Foreign Delegates: USD 175

Virtual Attendance:

Member: Kes 10,000 | Non-Member: Kes 12,000 | Foreign Delegates: USD 78

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12 CPDs

In This Issue

Call for Papers

Engineering In Kenya Magazine - Issue 023.

The Institution of Engineers of Kenya (IEK) publishes EngIneering in Kenya magazine, whose target audience includes engineering professionals, practitioners, policymakers, researchers, educators and other stakeholders in engineering and related fields. The publication is distributed to its target readers free of charge through hard and soft copies. IEK invites you to contribute articles for our next and future editions. Articles should reach the Editor not later than **20th July, 2025** for our next issue, whose theme iss **Food Engineering** and related sub-themes, across all engineering disciplines. An article can range from engineering projects to processes, machinery, management, innovation, news and academic research.

The articles must be well researched and written to appeal to our high-end readers in Kenya and beyond. The IEK Editorial Board reserves the right to edit and publish all articles submitted, in line with standing editorial policy. All articles should be in Word document format, 500-700 words, font type Times New Roman and font size 12.

Send your article today, and get a chance to feature in the magazine!

Send your article **editor@iekenya.org**

Eng. Prof. Lawrence Gumbe

Message from the Editor

Materials Science is the study of the properties of solid materials and how those properties are determined by a material's composition and structure. Materials Engineering involves the designing or engineering the structure of a material to produce a predetermined set of properties.

From a functional perspective, the role of a materials scientist is to develop or synthesise new materials, whereas a materials engineer is called upon to create new products or systems using existing materials and/or to develop techniques for processing materials.

Materials Science and Engineering (MSE) is an interdisciplinary field concerned with inventing new materials and improving previously known materials by developing a deeper understanding of the microstructure-composition-synthesis-processing relationships.

The term composition means the chemical make-up of a material. The term structure means a description of the arrangement of atoms, as seen at different levels of detail. Materials scientists and engineers not only deal with the development of materials, but also with the synthesis and processing of materials and manufacturing processes related to the production of components. The term synthesis refers to how materials are made from naturally occurring or human-made chemicals. The term processing means how materials are shaped into useful components. One of the most important functions of materials scientists and engineers is to establish the relationships between the properties of a material and its perflying relationships between the synthesis and processing, structure, and properties of materials. In materials engineering, the focus is on how to translate or transform materials into a useful device or structure.

Materials science has shaped the development of civilizations since the dawn of mankind. Better materials for tools and weapons have allowed humankind to spread and conquer, and advancements in material processing like steel and aluminium production continue to impact society today. Historians have regarded materials as such an important aspect of civilizations such that entire periods of time have defined the predominant material used including Stone Age, Bronze Age, Iron Age and Silicon Age.

For most of recorded history, control of materials had been through alchemy or empirical means at best. The study and development of chemistry and physics assisted the study of materials, and eventually the interdisciplinary study of materials science emerged from the fusion of these studies. The history of materials science is the study of how different materials were used and developed through the history of the Earth and how those materials affected the culture of the peoples of the Earth. The term Silicon Age is sometimes used to refer to the modern period of history during the late 20th to early 21st centuries.

In the early part of the 20th century, most engineering schools had a department of metallurgy and perhaps of ceramics as well. Much effort was expended on consideration of the austenite - martensite - cementite phases found in the iron - carbon phase diagram that underlies steel production.

The fundamental understanding of other materials was not sufficiently advanced for them to be considered as academic subjects. In the post WWII era, the systematic study of polymers advanced particularly rapidly. Rather than create new polymer science departments in engineering schools, administrators and scientists began to conceive of materials science as a new interdisciplinary field in its own right, one that considered all substances of engineering importance from a unified point of view. Northwestern University instituted the first materials science department in 1955.

Richard E. Tressler was an international leader in the development of high temperature materials. He pioneered high temperature fibre testing and use, advanced instrumentation and test methodologies for thermos-structural materials, and design and performance verification of ceramics and composites in high temperature aerospace, industrial and energy applications. He was founding director of the Center for Advanced Materials (CAM), which supported many faculty and students from the College of Earth and Mineral Science, the Eberly College of Science, the College of Engineering, the Materials Research Laboratory and the Applied Research Laboratories at Penn State on high temperature materials. His vision for interdisciplinary research played a key role in the creation of the Materials Research Institute. Tressler's contribution to materials science is celebrated with a Penn State lecture named in his honour.

The Materials Research Society (MRS) has been instrumental in creating an identity and cohesion for this young field. MRS was the brainchild of researchers at Penn State University and grew out of discussions initiated by Prof. Rustum Roy in 1970. The first meeting of MRS was held in 1973. As of 2006. MRS has grown into an international society that sponsors a large number of annual meetings and has over 13,000 members. MRS sponsors meetings that are subdivided into symposia on a large variety of topics as opposed to the more focused meetings typically sponsored by organizations like the American Physical Society or the IEEE. The fundamentally interdisciplinary nature of MRS meetings has had a strong influence on the direction of science, particularly in the popularity of the study of soft materials, which are in the nexus of biology, chemistry, physics and mechanical and electrical engineering. Because of the existence of integrative textbooks, materials research societies and university chairs in all parts of the world, BA, MA and PhD programs and other indicators of discipline formation, it is fair to call materials science (and engineering) a discipline.

The field of crystallography, where X-rays are shone through crystals of a solid material, was founded by William Henry Bragg and his son William Lawrence Bragg at the Institute of Physics during and after World War II. Materials science became a major established discipline following the onset of the Silicon Age and Information Age. This led to the development of modern computers and then mobile phones, with the need to make them smaller, faster and more powerful leading to materials science developing smaller and lighter materials capable of dealing with more complex calculations. This in turn enabled computers to be used to solve complex crystallographic calculations and automate crystallography experiments, allowing researchers to design more accurate and powerful techniques. Along with computers and crystallography, the development of laser technology from 1960 onwards led to the development of light-emitting diodes (used in DVD players and smartphones), fibre-optic communication (used in global telecommunications), and confocal microscopy, a key tool in materials science.

Material processing refers to the series of techniques and methods used to transform raw materials into finished products with desired properties and shapes. These processes involve manipulating the physical and chemical structure of materials to achieve specific characteristics, such as strength, hardness, flexibility, conductivity, or thermal resistance.

Material processing plays a crucial role in industries such as aerospace, automotive, construction, electronics, and medical devices.

According to Cognitive Market Research, the global Engineering Materials Market size was USD 62 billion in 2024. Some estimates put this figure at KES 800 billion in Kenya.

University engineering curricula for aeronautical, agricultural, biomedical, biosystems, civil, chemical, electrical, mechanical, mechatronic, production and petroleum engineering have elements of materials engineering. There is also research in these areas at the universities.

Materials engineering is a crucial area for the development of Kenya. This issue contains articles in this area. We hope that you will find them educative, informative and entertaining.

The IEK First African Journal of Engineering Research and Innovation (AJERI) will be held on 24- 25 July 2025 at Kenyatta University. This issue has an advert on how to register for the same. Please register and attend the conference as a presenter or participant. Quality research and innovation papers will be presented at the conference.

Eng Prof Lawrence Gumbe

Editor

Message from the President

Eng. Shammah Kiteme,
President, CE, FIEK, PMP

We are excited to be dealing with the subject of materials engineering in our issue 22. This subject is very important for any engineer. This is because for everything that an engineer does the final product must involve engineering materials. For this reason, an engineer has to be interested with the performance of materials just as the functionality of their designs.
Engineering involves application of science to solve practical solutions. Knowledge of materials is vital for every engineer. This is because the material properties determine the functionality of the designs.

Take the example of civil engineers. They design different structures to handle various forces. Whether structural engineers or highway and transportation engineers. They design structures from buildings to bridges to roads that must withstand design loads and not fail. The engineer will therefore want to understand concrete and its constituents and therefore its performance. Then how does the constituents affect its performance in different climate or environmental conditions?

This will inform whether the structure the engineer designs will survive under sulphate or chloride attacks in different environments. What material adjustments should be done on the concrete materials to ensures that the structures will perform optimally in these different environments. It's important to ensure that the structures will survive the extreme climatic conditions including oscillating heating and freezing and thawing and anything in between.

The microscopic properties of materials are a life and death issue for an aeronautical engineer for example. The structure of an aeroplane is very important and any crack in the body must be detectable from the onset and during regulator inspections. This will ensure that any onset of failure is noticed on time before a catastrophic failure occurs with detrimental consequences to the plane and the passengers. The aeronautical engineers will also be concerned with performance of materials at extremely high temperatures and pressures.

This is important because the balance of forces that creates aerodynamics of lift and thrust to maintain an aeroplane airborne are strong forces. From the smallest of the planes to the A380s and the biggest cargo planes the principal is basically a balance of forces. Materials Engineering is thus very important.

A mechanical engineer will want to understand the microstructure of the different alloys and their properties. Not just section properties but also the chemical composition that will influence their performance. This is why different alloys will be required with different constituents in terms of percentage compositions to achieve the ductility, malleability and different responses to fatigue. These are important aspects for engineer to consider. Materials engineering is as important for the industrial engineer, chemical engineer and production engineer as it is for the military engineer.

The chemical engineer will want to appreciate how the various processes will impact the various transportation options available and containment measures. The safety of engineering systems and processes is largely determined by the materials being handled. In this case, pressurised systems must be safe for handlers to safely handle them without dangerous explosions.

The Biomedical and hospital engineer will be interested with the performance of different materials in the sterile hospital environments. It is important to understand what infection control measures are applicable to what type of material. Disinfectants used in the clinical environment have an impact of corroding surfaces of the various facilities in the healthcare environment and the hospital engineer will be interested with this.

The advancement in materials science have created many opportunities for engineers. For example, the ability to engineer extremely light but strong materials have expanded the capacity for bigger and bigger planes. This has enabled increasing efficiency and economy in the aviation industry. Engineers are at the forefront of this and now it's possible to design very big planes. Of course, the limit of where they can take off or land is also a factor of consideration.
Engineering properties of materials will remain a big interest for engineers and this presents an opportunity for engineers to research and produce better and better materials for the various uses that engineers require them for. Advancements in quantum engineering, nanotechnology and other breakthrough research areas will remain at the forefront of this advancement.
Kenya needs to industrialize at a more increased rate than we have done since independence. This presents an opportunity for engineers to venture in modern material science, breakthrough research so as to be at the forefront of global advancement. This venture comes with other supportive industries including mining and all metallurgical processing required to convert minerals into finished products.
As a profession, we stand at a critical moment where the space of engineering practice and regulation must be enhanced, not inhibit research and innovation in emerging fields. Engineering continues to evolve and we cannot continue to focus on the traditional civil, electrical, mechanical and agricultural specializations. It is necessary to register an engineer who demonstrates great aptitude in materials engineering for instance. We must not force that Engineer to fit into the traditional four.
We are aware of the recent directives from the government on the fate of 42 state corporations. IEK organised a webinar on 27th May 2025 for Engineers to appreciate the journey the reforms have taken. The IEK council is engaged with different players at different levels in government with the view to ensure that the implementation of the cabinet recommendations will factor in the views of Engineers. It appears that the recommendations by the cabinet on defunding and declassification of the regulators means self-regulation. IEK is leading in this effort to ensure the transition is not disruptive to the interests of Engineers.
Self-regulation of professions may take different forms but it is desirable as it removes professional regulation from the armpit of the government and therefore their control by the government. It is for this reason that we must engage with the view to ensure that self determination that helps engineers have more say in their affairs is our sole goal and encompassing aim.
I now invite all our members to engage our well considered content of EiK issue 22 on Materials Engineering. This content is rich and it will educate, entertain and inform our members, partners and our various stakeholders.
We appreciate all who have continued to support this publication and we guarantee our members of a continued high quality reading publication in the future.

Eng. Jacton Mwembe

Message from the Honorary Secretary

Welcome to the 22nd edition of the EiK Magazine, themed "Materials Engineering."

Across the globe, materials engineering is increasingly recognized as a cornerstone of infrastructure development and industrial progress. In Kenya, we find ourselves at a critical junction, where the convergence of economic goals, environmental concerns, technological advancement, and policy reform necessitates a more thoughtful and transformative approach to the materials we use in engineering and construction.

We are seeing breakthroughs in fiber-reinforced composites, biodegradable plastics, recycled aggregates, and smart materials capable of responding to environmental changes. As Kenya ramps up efforts to meet its Nationally Determined Contributions (NDCs) under the Paris Agreement, the construction sector has come under increased scrutiny due to its high carbon footprint. Materials engineering sits at the nexus of this conversation. Concrete alone is responsible for about 8% of global CO_2 emissions—an alarming statistic that must inform every decision we make moving forward.

This edition explores low-carbon alternatives to cement, the promotion of recycled materials, and the use of bio-based products in construction. One of the featured technical articles takes a deep dive into "The Carbon Gap in Sustainable Housing and Infrastructure", outlining a life-cycle approach to design and materials selection.

For instance, cement manufacturing industries in Kenya are increasingly exploring and adopting advanced, low-carbon alternatives to traditional methods. This approach reflects the industry's proactive efforts to align with Kenya's national climate goals and global commitments to carbon reduction. By incorporating green concrete technology, manufacturers aim to replace 25% to 55% of traditional Portland cement, significantly reducing environmental impact and promoting climate-friendly construction practices.

The IEK has formed the manufacturing task force that oversees the trainings insights and promotes the advice on the dynamics related to manufacturing in Kenya and beyond. These steps of developments reflect a growing maturity in our understanding that the future of infrastructure is not just about building more—but building smarter.

Kenya is currently experiencing an infrastructure boom—from roads and bridges to affordable housing and renewable energy systems. However, this rapid growth presents a paradox. On one hand, we need large volumes of materials; on the other, we face increasing pressure to meet sustainability, quality, and affordability metrics.

The success in relation to economies of scale with regards to the Affordable Housing can never be under estimated.

The IEK council has continuously emphasized the need for integrated policy frameworks that enable innovation without compromising quality or safety. We have signed various memorandums of understandings with agencies like Kenya Bureau of Standards (KEBS), Engineers Board of Kenya (EBK), National construction authority, NCA, and other professional and academic institutions that are instrumental in strengthening safety and quality frameworks and standardization compliance of Materials availability in Kenya with the national and global codes.

Materials testing at the point of importation remains a critical factor in shaping the quality and performance of infrastructure projects. Through advanced testing and dedicated Research and Development (R&D), engineers play a pivotal role in ensuring quality assurance—especially in key sectors such as roads and housing. This approach reflects global trends, where materials research is increasingly seen not as an academic pursuit, but as a strategic national investment in long-term infrastructure resilience and economic growth.

The Institution of Engineers of Kenya (IEK) continues to champion collaborative research among industry stakeholders to enhance quality in engineering education and materials science. This edition highlights the role of Kenya's Materials Testing and Research Directorate (MTRD) in advancing these efforts. Through cutting-edge testing, certification, and innovation, MTRD ensures construction materials meet top standards of safety, quality, and sustainability.

The IEK is deeply committed to benchmarking our Engineering related matters of progress against global best practices. Countries like Germany, South Korea, and Singapore have integrated materials research into their national industrial strategies, making materials engineering central to their economic transformation. In Africa, nations like South Africa and Morocco are emerging leaders in recycled construction materials, green cement, and smart infrastructure. Kenya has every opportunity to join this league of forward-thinking countries. But to do so, we must commit to sustained investment in technical capacity, industry-academia collaboration, and regulatory enforcement. We must also empower our youth—our future engineers.

The contribution featured from the students from various Universities in this issue gives us a glimpse of the next generation of engineering thought leaders.

At the heart of IEK's mission is policy advocacy. Materials are not just an engineering issue—they are a governance issue, a public safety issue, and an economic development issue. That is why we are advocating for stronger regulatory frameworks through the EBK, including the creation of mandatory materials audit mechanisms for large-scale projects and accreditation systems for testing laboratories.

One of the articles in this issue "Safeguarding the built environment: engineering regulation for a safer, stronger Kenya" by EBK provide us with key safety measures in the built environment. This sector is governed by a strong legal and institutional framework, with the EBK working collaboratively with the IEK and other key regulators at the core of Engineering matters —ensuring engineers and projects meet safety, quality, and ethical standards.

Despite notable progress, challenges such as regulatory bypassing, weak enforcement, and technical gaps persist, occasionally resulting in unsafe structures. In response, EBK has launched strategic reforms aimed at elevating engineering standards, improving digital oversight through project registration portals, and enhancing inter-agency coordination.

This issue of EiK is not just a collection of articles—it is a call to action. Whether you're a practicing engineer, policymaker, student, contractor, or manufacturer, you will find knowledge, insights, and inspiration within these pages. But more than that, we hope you will find a reason to act—to advocate for better materials policies, to adopt sustainable practices, and to collaborate in building Kenya's future.

In conclusion, I wish to thank all contributors, partners, and the Editorial Board for their commitment to making this publication a success. Let us continue to place excellence, integrity, and innovation at the center of our work as engineers.

Read deeply. Think critically. Apply wisely. Advocate passionately.

Enjoy the issue.

Sustainability and Life Cycle Assessment of Structural Elements

Eng. Nathaniel Matalanga

Engineer Nathaniel Matalanga is a man of many firsts and a decorated engineer. A consulting engineer who deals with structural designs of buildings and surrounding infrastructure. Eng. Matalanga was the president of the Institution of Engineers of Kenya for the 2020/2022 period, and also served as Honorary Secretary. He is an Executive Council Member of the World Federation of Engineering Organization since 2019. After his stint as Treasurer of the World Council of Civil Engineers in2021-2024, he was elected President with his tenure set to begin in 2027. He sits at the helm of Ngasi Consulting Engineers, a consultancy which has been in operation for 30 years. Eng. Matalanga was conferred the Order of Grand Warrior (OGW) by retired President of Kenya Uhuru Kenyatta in 2021. Engineer is a man full of wisdom and insight, who expresses himself with great precision and intellect. When we sat with him to discuss Sustainability and Life Cycle Assessment of Structural Elements, this is what he had to say:

Being a strong advocate for sustainable infrastructure, how do you envision civil engineers leading the transition toward sustainability in the construction of structural elements?

One of the goals of civil engineering is the creation of sustainable infrastructure; infrastructure that minimizes environmental impact. All of this calls for the use of sustainable materials that reduces energy consumption and designing systems that are both efficient and resilient. This remains a core consideration for civil engineers - to design systems that are not only economically, or financially feasible but are also sustainable.
Social sustainability is yet another key pillar of these designs, as the needs and the impact of the local community takes center stage towards the drive for social equity. Good infrastructure should benefit all stakeholders. When the Nairobi Expressway was being constructed for instance, it was heavily rumored that it would solely benefit the rich, but overtime, it has become an all-important fixture in this city's logistics.

As a civil engineer, it is imperative that you remain well within the realms of sustainability, and to achieve this, there is need to develop pro-cost institutions, frameworks and government structures that support long term maintenance and adaption of infrastructure. Sustainable infrastructure goes well beyond brick-and-mortar structures, it includes building resilient systems that can absorb shocks and stresses like climate change, socio-economic challenges in the lead-up to achieving sustainable development goals. The UN Sustainable Development Goals (SDGs) call upon us to reduce environmental impact, use materials with a lower carbon footprint, protect eco-systems and promote resource efficiency. In Africa especially, there is an urgent need for systems that support long term economic development and financially viable infrastructure.

Life Cycle Assessment (LCA) has become a key tool in evaluating environmental impacts of building materials and systems. How do you see LCA influencing decision-making in structural design across developing economies, especially in Africa?

In order to achieve sustainability, you have to consider the total lifespan of the system you are designing. The product needs to be clearly defined from the initial design stage. Just as important is the Life Cycle Inventory which involves collecting all the input/output data related to the product life cycle. This includes the raw materials, energy use during the construction process, transporting the raw materials to the site and the actual construction process. The Life Cycle Impact Assessment evaluates the impact of the product on factors like global warming, potential resource depletion and human toxicity.

A major benefit of the Life Cycle Assessment is the foresight when it comes to identifying environmental impacts, which then informs the decision on materials and the construction process in its entirety, it provides crucial data for sustainable product design and choice of materials.

In your experience, what are the main challenges engineers face when incorporating LCA into the design and construction of infrastructure projects?

Three challenges stand out in the case of Kenyan engineers: insufficient data, lack of resources and lack of standard procedures. These challenges hinder the ability and capacity to accurately assess the environmental impact products and processes. I will give an example of the choice of cement in physical construction sites: there are cement companies popping up every other day yet the process of making this cement is hardly documented. It is difficult to tell how much energy has been used in the manufacture of the cement, how much cement goes into achieving a specific grade of concrete – this information is vital in gauging the direction and impact of the process. There is a general unwillingness in sharing the manufacturing process which makes it relatively difficult to assess the environmental impact of both products and process.

A key player here, so to speak, is the government which does not always provide funding for these 'side processes. Yet another pressing challenge is the fact that most major infrastructure projects are designed by non-locals who have even less access to data and less knowledge of these challenges.

Short project timelines hinder complete feasibility studies and impact assessments. It can be difficult for local engineers to conduct full Life Cycle Assessment of a project before the design. A good example again is the Expressway where the local engineers were only invited to see to its completion in the given timeline after it was already designed and a contractor was already in place.

The private sector is relatively flexible as they give enough time to come up with an economical design, but then, the private sector hardly invests in huge infrastructure projects, that is mostly done by the government which does not have a strong regulatory and enforcement framework. There is a deep need to appreciate how important the Life Cycle Assessment is to the outcome of the project.

How can these challenges be countered?

Training and education need to be factored in when it comes to setting aside funds for projects. Knowledge and skills development for engineers in conducting the Life Cycle Assessment is vital. There is need for clear interpretation of the results, the exercise needs to be done in a standard way so the conclusions are similar.

We are currently pushing for international recognition of our engineers, which requires us to familiarize ourselves with international best practices. Therefore, our engineers need to access international training, seminars and workshops to bring them at par with these set standards, on top of meeting the minimum education levels and practice. Our regulatory board, that is the Engineers Board of Kenya, is pushing for being part of the Washington Accord which will have us demonstrate the highest best practices and access funding to ensure the same.

There is the matter of corruption, which if we manage to overcome will open up the environmental policies and it will be much easier to adopt sustainable practices.

Despite these challenges, can you share any standout examples or best practices from Kenya or the broader African region where sustainability and LCA have been effectively integrated into infrastructure projects?

There are actually very many standout projects despite the challenges. The thing with engineering is, we wake up every day to solve problems and overcome challenges, and in our own way we do this. The Lake Turkana Wind Power Project is one of the largest wind power plants in Africa which not only demonstrates a commitment to renewable energy but also reduces reliance on fossil fuels. It greatly contributes to the regional energy independence. The Life Cycle Assessment was done properly and we got it right.

The Addis Ababa Light Rail Transit System in Ethiopia is yet another great example of sustainability by reducing urban decongestion and air pollution. The Life Cycle Assessment of this project focused on energy consumption, emission and waste management, and it provides valuable insight for sustainable urban transport in other African countries.

Here in Kenya, the government and the private sector have made significant steps towards sustainability especially with the use of locally sourced materials, promoting energy efficient building designs and implementing green building certification. Using locally sourced materials saves on transportation costs which in turn reduces energy and the carbon footprint. Many African countries are using solar-powered water pumps and desalinization units to promote clean water access in remote communities. This reduces reliance on diesel generators, lowers energy costs and minimizes the negative impact on the environment.
We need to integrate sustainability into the planning of the project. Early integration into the initial planning phases of the project allows for informed decision-making while taking to mind the identified environmental and socio-economic impact.

As the President-elect of WCCE, and the first African to achieve this fete, how do you plan to elevate the global visibility of African engineering expertise in sustainable infrastructure development?

My term as the President of the World Council of Civil Engineers starts in 2027 and my vision is to focus on knowledge sharing, capacity building and promoting African-led solutions. You know, in Africa we have very good examples of great engineering fetes, like the Egyptian pyramids which we never seem to fully appreciate yet they confound the engineering word to this day. My hope is to leverage partnerships, supporting research and highlighting African successes in infrastructure projects and technologies.

At a world level there is need to explore the possibility of networks and partnerships. I plan to strengthen collaborations with the international collaborations like the World Federation of Engineering Organization where I am also Executive Council Member and UNESCO which works very closely with WFEO to share best practices and expertise.

Moreover, I plan to facilitate exchange programs for faculty and people in the teaching space and student exchange programs between African and international universities to enhance skills and knowledge transfer. As I mentioned earlier, there is a need to attain international recognition so engineering education in Kenya is elevated to the world standard. Today's technology thankfully allows us to create digital platforms to disseminate information on African engineering innovations and solutions.

I will advocate for the inclusion of women in the engineering profession and infrastructure projects recognizing their vital role in achieving sustainable development goals. My desire is to promote knowledge-sharing and capacity building in disaster and risk reduction, focusing on building resilient infrastructure and protecting vulnerable communities.

Looking ahead, what skills and competencies should the next generation of civil engineers develop to stay ahead in sustainability and life cycle thinking?

Critical thinking and problem solving, and a heightened awareness of environmental sustainability, proper and efficient construction management coupled with artificial intelligence, machine learning, data analysis, renewable energy engineering are some of the skills and competencies the next generation of civil engineers develop. Cyber security in relation to the security of infrastructure systems is just as important as destroying these systems is very easy yet building them takes so much effort.

Parting shot

If properly embraced, engineering is capable of propelling our country to the next level. There were several engineering fetes during the time of President Kibaki and President Uhuru, the stagnation we are currently experiencing stems from a lack of appreciation of the space of an engineer. There is a general lack of appreciation for professionalism by politicians. Decisions are being made without professional input. When Cabinet memos come out it sometimes get difficult to pinpoint the informed, professional touch behind some proposals. There have been calls to delist and defund professional bodies at a time that the government has invested in projects that greatly require professional advice. The 'what is in it for me' thinking will lead this country into a deep hole, and we might lose everything we have achieved.

All of us need to push to go back to professionalism- when making an engineering decision, listen to the right engineer, when making a legal decision, listen to the lawyer, when there is a medical issue, listen to the doctor. For us to achieve sustainable infrastructural developments, we need to have an engineer in the middle, an engineer at the top running it and an engineer at the end ensuring that the entire process meets engineering principles, and that way we will go through the full life cycle of developing our country sustainably. This is an idea that we could sell to the politicians, but then one would ask, why then shouldn't the engineers join politics? Not all engineers can join politics, some of us need to remain at the technical level and to advise. Our call is that politicians make decisions that are professionally-backed.

Unlocking Global Engineering Opportunities for Kenya: Implications of Global Accreditation of Engineering Programs

Eng. Margaret Ogai, CE, FIEK, Registrar and Chief Executive Officer, EBK

Historic Milestone

On 12th June 2025, at the International Engineering Alliance Meeting 2025 in Merida, Mexico, Kenya achieved a historic milestone as Engineers Board of Kenya acceded to the Washington Accord as a Provisional Signatory.

This milestone was a culmination of concerted efforts from 2019 by Engineers Board of Kenya under mentorship of Board of Engineers Malaysia and Pakistan Engineering Council and supported by key stakeholders including universities offering engineering programs, Council of Engineering Deans and Principals, the Commission for University Education (CUE) and engineering professionals who were trained assessors drawn from academia and industry nominated by Institution of Engineers of Kenya (IEK) and Association of Consulting Engineers (ACEK).

This significant milestone of Kenya acceding to the Washington Accord creates opportunities for engineering skills made in Kenya to be exported around the world, minus need for retraining, and will secure job opportunities for thousands of Kenyan engineering graduates to offer their expertise on engineering projects around the world.

The Engineers Board of Kenya (EBK) is mandated to recognize engineering programs offered both locally and internationally to ensure they meet global standards. Engineers Board of Kenya, in its regulatory mandate, has been actively engaging and working closely with universities across the country that teach engineering programs to align their programs to outcome based which EBK then validates and accredits programs to ensure they match international standards set by IEA.

As Kenya continues to position itself as a regional and global hub for innovation, infrastructure, and sustainable development, the Engineers Board of Kenya (EBK) has committed to align its engineering education and professional frameworks with international standards within the next four year.

The Washington Accord is a multi-lateral agreement under IEA that recognizes the substantial equivalence of engineering degree programs accredited by its signatories. It allows for the global mobility of engineering graduates, meaning Kenyan engineers trained in locally accredited programs will be eligible to work, register, or pursue further studies in other signatory countries without undergoing extensive requalification.

Implications for Kenya's Engineers will include:

1. Global Mobility and Recognition

Upon joining the Washington Accord, engineering graduates from accredited Kenyan programs will enjoy recognition in over 20 countries, including Australia, Canada, the UK, the US, Japan, and more. This enhances competitiveness and eases access to employment or postgraduate education abroad.

On the regional front, Kenya is an active member of the East African Community Mutual Recognition Agreement (EAC MRA) for Engineers, facilitating cross-border practice in the region. Moreover, under the African Continental Free Trade Area (AfCFTA), EBK is playing a strategic role in the formulation of the Africa Accord under the Federation of African Engineering Organizations (FAEO). This emerging continental framework will standardize engineering qualifications across Africa and is expected to increase intra-African trade in services from 15% to 25%.

2. Improving Engineering Training Standards

To meet the Accord's rigorous requirements, EBK has strengthened its accreditation framework to international best practice. To date, EBK has recognised over 90% of eligible engineering programs to set standards in Engineers Rules, 2019 in collaboration with the Commission for University Education.

3. Enhanced delivery of quality engineering

Kenya's delegation led by EBK Chairman and Registrar pose for photo with Chairman of Washington Accord at International Engineering Alliance Meeting 2025 in Merida, Mexico immediately after acceptance for Kenya to join as provisional signatory of WA. Photo Courtesy/Engineers Board of Kenya services for national development

Global accreditation is not just about mobility—it is also about transforming Kenya's development trajectory. By benchmarking local training to international standards:

- Infrastructure projects are delivered with better quality assurance.
- Investors gain confidence in Kenya's human capital.

4. Training of Graduate Engineers

EBK's Graduate Engineers Internship Program (GEIP), funded by Government, already places a 100 young engineers in industry each year. With greater international credibility, the program is poised to expand through partnerships, helping to address the current 40% unemployment rate among engineering graduates. Thus youth employment is set to be enhanced as engineering becomes a global export skill.

Kenya's admission to the Washington Accord will be more than symbolic—it is a strategic asset in positioning the country as a knowledge economy. It opens doors to collaborative research, innovation exchanges, and engineering export services.

EBK remains committed to:

- Ensuring 100% local recognition of engineering programs by 2025,
- Finalizing the digital exchange platform for cross-border registration under EAC MRA,
- Supporting national goals like Vision 2030 and BETA through supply of globally competent engineers in all sectors of our economy.

The journey to global accreditation is a national win —not just for engineers, but for the entire country. It is a call to universities, industry, government, and the engineering community to rally behind this transformation. This affirms Kenya's readiness to stand shoulder to shoulder with the world's top engineering nations and provide solutions to improve quality of life for all.

ENGINEERS BOARD OF KENYA

Enhancing Professionalism

HISTORIC MILESTONE:
KENYA ACCEDES TO WASHINGTON ACCORD: ENHANCING GLOBAL MOBILITY FOR KENYAN ENGINEERS

Kenya's delegation led by EBK Chairman and Registrar pose for photo with Chairman of Washington Accord at International Engineering Alliance Meeting 2025 in Merida, Mexico immediately after acceptance for Kenya to join as provisional signatory of WA. *Photo Courtesy/Engineers Board of Kenya.*

NAIROBI, KENYA – June 13, 2025 – The Engineers Board of Kenya (EBK) proudly announces Kenya's official accession to the Washington Accord, formalized by a unanimous vote at the International Engineering Alliance Meeting (IEAM) held in Merida, Mexico, on June 13, 2025.

This landmark achievement represents a pivotal moment for engineering education in Kenya and global mobility for Kenyan engineers. The Washington Accord, a multilateral agreement, ensures global recognition and substantial equivalence of accredited engineering programs, enhancing global mobility of engineers and upholding international quality benchmarks.

EBK extends its profound gratitude to all stakeholders, including the Government of Kenya, the Ministry of Roads and Transport, accredited training institutions, professional engineers, and international partners, whose unwavering support enabled this significant milestone. This accession marks a new chapter for the Kenyan engineering profession, reinforcing EBK's commitment to regulatory oversight, ethical practice, and sustainable development.

Renewable Energy solutions, energy efficiency in manufacturing, smart grid's energy integration for industrial applications

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Abstract

The global shift towards clean cooking solutions is essential for sustainable development and reducing greenhouse gas (GHG) emissions. This paper presents an affordable and efficient smart biogas system project implemented in Kisii County and designed to align with this shift, using a pay-as-you-go model to make clean energy accessible to economically disadvantaged populations. The system enhances financial resilience by allowing users to pay in installments, eventually leading to ownership of the system, thus supporting the global agenda for access to affordable and sustainable energy for all and climate action. The smart biogas system provides a reliable and clean energy source, crucial for poor communities. It offers long-term benefits, including reduced deforestation, decreased prevalence of respiratory diseases caused by dirty fuel cooking, and significant contributions to global sustainability goals. By replacing traditional fuels with biogas, the system also helps mitigate the adverse health effects associated with indoor air pollution. Furthermore, the project emphasizes the importance of training and sensitizing local community members. This approach not only fosters the adoption of clean cooking technologies but also builds capacity, enhances employability, and spurs economic growth through job creation. The involvement of local stakeholders ensures that the community can sustain and expand these benefits over time. This study underscores the potential of smart biogas systems as a viable solution for addressing energy poverty, promoting environmental sustainability, and achieving socio-economic development. It serves as a model for similar initiatives worldwide, highlighting the critical role of innovative, inclusive approaches in advancing global climate and energy goals.

Keywords: Smart Biogas System, Pay- as- You-Go model, Green House Gases, Sustainable energy

Background Study

Kenya, like many developing nations, faces significant challenges in energy access, particularly for rural populations who rely heavily on traditional biomass for cooking. In rural areas such as Kisii County, firewood and charcoal remain the predominant cooking fuels, contributing to deforestation and greenhouse gas emissions. The country's Vision 2030 and commitment to Sustainable Development Goal 7 (SDG 7) emphasize the need for affordable, reliable, and sustainable energy access for all Kenyans. Additionally, indoor air pollution caused by the use of biomass fuels leads to respiratory illnesses, particularly among women and children, further underscoring the urgency for clean cooking solutions.

In this context, biogas technology offers a renewable and cleaner alternative to conventional fuels, converting organic waste into methane that can be used for cooking (Smith et al. ,2014). However, the upfront cost of biogas systems has historically been a barrier for economically disadvantaged populations. The introduction of a Pay-As-You-Go (PAYG) model, coupled with a smart biogas system, addresses this challenge by allowing users to acquire the system through manageable, incremental payments (Taneja, 2018). This project in Kisii County illustrates how such innovative financial models can promote clean energy adoption, reduce health risks, and support environmental sustainability, all while contributing to Kenya's broader energy access and climate change mitigation goals. Furthermore, Kenya has implemented various energy policies, such as the Energy Act of 2019 and the National Climate Change Action Plan (NCCAP), to promote renewable energy solutions. Mwangi and Wangeci (2020) argue that Kenya's push towards renewable energy aligns with its long-term environmental and socio-economic objectives. Therefore, integrating biogas technology into this policy framework is a logical step toward achieving the country's renewable energy targets.

Case study: Kegati Village, Kisii County

The smart biogas system was undertaken in Kegati Village in Kisii county in collaboration with Power Africa and YALI RLC. This project entailed sensitizing and training community people on the adoption of smart biogas system. This was crucial in imparting employable skills and building capacity among the community people. This project targeted community members who could leverage on the household organic wastes and animal wastes to produce clean biogas.
A sample survey study done in the select region showed that a larger percentage of the community members possess 1-3 cows which could produce enough feed stock for the deployment of the biogas system. Through the Pay As You Go Model, the community members will be able to acquire a sizable biogas system. This will eradicate indoor air pollution and promote circular

economic principles in the context of waste recycling. Furthermore, the beneficiaries will access nutrient rich slurry for organic fertilizers.

Methodology

This study employed a mixed-methods approach, combining qualitative and quantitative data to assess the impact of the smart biogas system implemented in Kisii County. The project was carried out in collaboration with local stakeholders, including households, government agencies, and USAID's Power Africa.

Site Selection

Kisii County was selected due to its heavy reliance on traditional biomass fuels and its suitability for biogas technology given the availability of organic waste from agriculture and livestock.

Figure 1: Kegati Village, Kisii County

System Design and Installation: The smart fixed dome type biogas system was designed to accommodate the energy needs of rural households. Each system was equipped with a biogas digester that converts organic waste into methane gas, and a PAYG meter for monitoring usage and payments.

Figure 2: Fixed-dome type biogas plant

4. Capacity Building and Sensitization: Community members received training on the operation and maintenance of the biogas system, as well as the environmental and health benefits of adopting clean cooking solutions.

Results and Discussion

The implementation of the smart biogas system in Kisii County illustrates the transformative potential of renewable energy technologies when paired with innovative financial models like Pay-As-You-Go (PAYG). By addressing the affordability barrier, the project has enabled economically disadvantaged households to access clean energy, significantly reducing their reliance on traditional biomass fuels. This shift has led to a noticeable decrease in deforestation and indoor air pollution, directly improving environmental and health outcomes.

One key strength of this project lies in its holistic approach, which integrates not only the provision of technology but also community engagement and capacity building. By training local residents in the operation, maintenance, and benefits of the biogas systems, the project has empowered the community, fostering a sense of ownership and sustainability. The

inclusion of local stakeholders ensures that the systems remain operational long after the initial implementation, contributing to the long-term success of the initiative.

The PAYG model has also proven effective in ensuring financial inclusivity. Households that would typically be excluded from clean energy solutions due to high upfront costs were able to adopt the biogas system gradually. The flexibility of the payment structure helped households manage their finances while gaining access to a reliable and sustainable energy source.

However, further exploration is needed to understand the long-term sustainability of the PAYG model, particularly in regions where economic fluctuations could affect payment compliance. Additionally, scaling this project to other regions will require strong partnerships with government agencies and private sector players to ensure that the necessary infrastructure and support systems are in place.

Impact

The implementation of the smart biogas system in Kisii County has yielded several positive outcomes:

1. Environmental Impact: There was a significant reduction in deforestation, with participating households reporting a 70% decrease in firewood use. This translates to a measurable reduction in greenhouse gas emissions, contributing to both local environmental sustainability and global climate goals.

2. Health Benefits: Households using the biogas system reported a marked reduction in respiratory illnesses, particularly among women and children, who are most exposed to indoor air pollution. The use of clean biogas for cooking virtually eliminated harmful smoke emissions.

3. Economic Impact: The PAYG model allowed economically disadvantaged households to access clean energy without the burden of high upfront costs. The flexible payment system ensured that households could pay according to their financial capacity, leading to an increase in system adoption.

4. Community Empowerment and Job Creation: The project created employment opportunities for local technicians who installed and maintained the systems. Furthermore, the capacity-building initiatives enhanced the skills and employability of community members, contributing to local economic development.

Figure 3: Sample dome type biogas system developed at Kegati Village

Conclusion

The smart biogas system, coupled with the PAYG model, is a viable solution for addressing energy poverty in rural Kenya. It not only provides a clean and affordable energy source but also contributes to environmental conservation, improved public health, and socio-economic development. The results from Kisii County demonstrate the potential of this approach to be scaled up in other regions of Kenya and beyond, serving as a model for similar clean energy initiatives worldwide.

Recommendations

$_2$Scaling Up: The success of the Kisii County project highlights the need for broader implementation of smart biogas systems across other rural areas in Kenya. Government support and public-private partnerships can play a crucial role in scaling up the project.

2 Policy Integration: To enhance the impact of biogas technology, the Kenyan government should integrate smart biogas systems into national energy policies and provide subsidies or incentives for wider adoption.

2 Long-term Monitoring: Future projects should include long-term monitoring and evaluation to measure the sustained impact of biogas systems on household energy use, health outcomes, and environmental conservation.

2 Training and Capacity Building: Continued investment in community training programs is essential to ensure the long-term sustainability of the systems and to expand local job creation.

Acknowledgement

The authors would like to extend their sincere gratitude to Power Africa and the Young African Leaders Initiative (YALI) Regional Leadership Center (RLC) for providing the essential funding and support for this project. Without their financial assistance, the implementation of the smart biogas system in Kisii County would not have been possible. Their commitment to advancing clean energy solutions and empowering local communities has played a crucial role in the success of this initiative.

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Evaluating Shear Properties and Structural Performance of Custom I-shaped Engineered Timber for Sustainable Construction

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ABSTRACT

The construction industry faces significant environmental challenges, particularly from resource depletion and waste generation. In response, engineered timber, specifically Cross Laminated Timber (CLT), has emerged as a sustainable alternative construction material. CLT, made from layers of wood planks arranged crosswise, offers exceptional strength and stability for various applications, including mass timber buildings. However, CLT is prone to shear failure, especially in complex structures. This research investigates the potential of custom I-shaped CLT panels to mitigate shear issues in floor construction. The study establishes the shear properties of standard block configurations and evaluates the shear characteristics of newly developed custom I-shaped panels. It compares the structural performance of eucalyptus and grevillea wood species in these engineered panels. Laboratory tests focused on shear and bending strength, utilizing properly seasoned timber while excluding tree age considerations prior to logging. Key findings reveal that I-Section eucalyptus panels exhibit a 20.46% higher Modulus of Elasticity (MOE) and a 26.61% higher Modulus of Rupture (MOR) than I-Section grevillea panels, indicating increased stiffness and load-bearing capacity. Eucalyptus also shows 7.1% greater shear strength than grevillea, making it suitable for applications requiring enhanced shear resistance. However, grevillea offers better compression strength and hardness for specific construction scenarios. Overall, custom I-shaped panels significantly improve shear resistance compared to standard block configurations, reducing the risk of shear failure in CLT-based structures.

Keywords - Cross Laminated Timber (CLT), Shear resistance, Eucalyptus, Grevillea, Modulus of Elasticity (MOE), Modulus of Rupture (MOR).

1. INTRODUCTION

Cross Laminated Timber (CLT) is an engineered wood product constructed by bonding multiple layers of timber boards at right angles. It is increasingly favored for its strength, sustainability, and ability to replace traditional building materials like steel and concrete. CLT is environmentally friendly, as it utilizes renewable resources and reduces carbon emissions (Barbhuiya, 2023). These factors align with the growing demand for eco-conscious construction practices. CLT is used in walls, floors, and entire building structures, and its large panels enable efficient, rapid construction. This reduces labor costs and time, making it an attractive solution for modern construction projects (Bechert et al., 2021).

The strength and performance of CLT are key reasons for its growing use in tall buildings and complex architectural designs. For instance, the Brock Commons Tallwood House in Canada and the Mjøstårnet in Norway, two of the tallest timber structures globally, demonstrate the structural versatility and potential of CLT. These buildings highlight CLT's high strength-to-weight ratio and the ability to integrate CLT elements with concrete and steel for enhanced performance (Ilgin & Karjalainen, 2022)

2. LITERATURE REVIEW

Shear failure in CLT structures is a significant challenge. Shear forces, particularly out-of-plane, can cause excessive deflection and rolling shear failure, compromising the structure's integrity (Ayanleye et al., 2022). Poor installation practices, inadequate panel connections, and exceeding design loads exacerbate this issue. In the absence of standardized design codes tailored to CLT, engineers must adapt existing codes, often overlooking CLT's unique characteristics (Aloisio et al., 2022).

Research has expanded to study factors such as adhesive type, panel thickness, and boundary conditions that affect CLT's shear properties. By optimizing these factors, CLT can better resist shear forces, reducing the risk of failure (Angelucci et al., 2022). Shear failure is particularly concerning in CLT due to wood's orthotropic nature, meaning its properties vary along its three axes: longitudinal, tangential, and radial (Johansson, 2016). Understanding these properties is crucial when designing structures to withstand shear stress, especially as wood exhibits a viscoelastic nature, combining elastic and plastic behaviors.

Custom structural panels, especially I-shaped CLT panels, offer an innovative solution to the shear failure issue. Engineers design these custom shapes to optimize load distribution and improve shear resistance, akin to pre-engineered steel sections. The slenderness of the flange and web in these sections plays a crucial role in improving shear resistance and stability (Qureshi, 2018). Custom-shaped timber elements not only enhance structural efficiency but also contribute to sustainability by reducing material usage and carbon emissions (Shuttleworth, 2023).

Beyond structural benefits, custom CLT panels allow for greater design flexibility, offering architects the opportunity to create visually appealing and innovative designs (Monarch et al., 2020). These panels align with sustainable building practices, as their manufacturing process is energy-efficient compared to concrete and steel. The responsible sourcing of timber for CLT ensures adherence to sustainable forest management principles, preserving ecosystems and reducing the environmental impact (Jensen & Craig, 2019).

CLT's environmental benefits extend beyond construction, as its energy-efficient manufacturing reduces emissions during production and transportation. Additionally, CLT structures inherently generate less onsite waste than traditional materials (Ding et al., 2022). The long-term durability of CLT, especially when customized for specific environmental conditions, minimizes the need for replacements, further reducing environmental impact (Pierobon et al., 2019).

Despite CLT's advantages, the construction industry faces a research gap in addressing shear failure, especially in complex buildings. While existing research has primarily focused on standard CLT block configurations, little attention has been given to the development of custom I-shaped sections. These sections hold promise for enhancing shear resistance and structural integrity, especially in floor constructions, by redistributing and efficiently transferring shear forces. Developing innovative solutions to counteract shear deformation can significantly improve the safety and longevity of CLT-based structures (Mayencourt & Mueller, 2020).

3. METHODOLOGY

3.1 Material sourcing

Eucalyptus and Grevillea timber were sourced from Gikomba Market. Structural timber sections, including block and I-sections, were assembled using Polyvinyl Acetate adhesives, which are widely available in the Kenyan market.

3.2 Experimental Program

Experimental analysis of structural timber sections of block and I-sections using Polyvinyl Acetate adhesives on Eucalyptus and Grevillea were performed. Timber was inspected for defects, cut into segments, and strategically laminated with adhesive applied both along and across the grain. The laminated elements were tightly bound with manila string and subjected to cold pressing at room temperature, applying 200 tons of top force and 100 tons of side force. After overnight curing, the laminated sections were tested according to BS EN 384:2016+A2:2022 and BS EN 408:2010+A1:2012 for structural timber and glued laminated timber. The various samples sizes for testing are as shown in figure 3.1

Figure 3.1 Samples sizes for testing

3.3 Laboratory Tests

Compression tests were performed with standard specimens (2 cm x 2 cm x 6 cm) parallel to the grain per BS EN 384:2016+A2:2022, loading at 0.025 in/min until failure to determine compressive strength.

Compression tests perpendicular to the grain applied loads between parallel plates in radial and tangential directions, also at 0.025 in/min, recording maximum load and strain at 0.1 in. Shear tests followed BS EN 408:2010+A1:2012 using 2 cm cubes, loading at 0.025 in/min until failure. For Static bending tests as shown in figure 3.2, specimens (2 cm x 2 cm x 30 cm) underwent central loading at 0.26 in/min per BS EN 408:2010+A1:2012, measuring mid-length deflection until failure. Janka hardness tests assessed workability using 10 cm x 2 cm x 2 cm specimens, loading at 0.025 in/min until failure. Lastly, moisture content tests adhered to BS EN 13183-1, where timber weights were recorded before and after 24-hour oven drying to calculate moisture content as a percentage difference, ensuring optimal machining and strong glue joints.

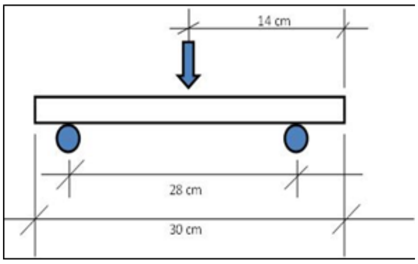


Figure 3.6: Static bending test setup dimensions

4. RESULTS, ANALYSIS AND DISCUSSION

4.1 Results

The results presented in table 3.1 highlights the engineering properties of eucalyptus and grevillea timber, comparing their performance in normal, block CLT, and I-section forms.

Eucalyptus consistently outperforms grevillea in terms of density, compressive strength, flexural strength (MOR), modulus of elasticity (MOE), and Janka hardness. I-section specimens exhibit the highest values in MOE, MOR, compressive strength, and shear strength, indicating superior load-bearing capacity emerging as the most promising for construction use due to its enhanced strength and stiffness. The Static bending and the overall performance metrics of various specimen is as shown in figure 4.1. and 4.2 respectively.

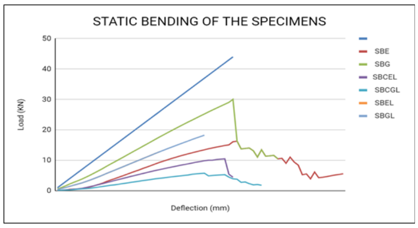


Figure 4.1: Static bending of various specimen

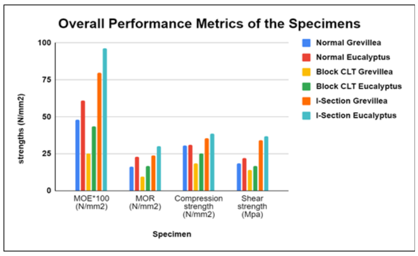


Figure 4.2: Specimen Overall Performance Metrics

4.2 Discussion

4.2.1 Engineering Properties of Normal Timber

The investigation into the engineering properties of eucalyptus and grevillea timber provides vital insights into their construction suitability, particularly for structural applications like floors and walls. Eucalyptus has a higher density (0.62 g/cm³) than grevillea (0.54 g/cm³), sug-

SUMMARY	MOE (N/mm^2)	MOR (N/mm^2)	Compression strength (N/mm^2)	Density (g/cm^3)	MC %	Shear strength (Mpa)	Average Hardness
Normal grevillea	4,825.47	16.17	30.59	0.54	34.78	18.65	2.56
Normal eucalyptus	6,123.18	23.09	30.92	0.62	40.31	22.00	4.04
Block CLT grevillea	3540.26	10.76	18.55	0.54	23.92	14.02	2.54
Block CLT eucalyptus	4365.71	16.97	25.2051	0.66	20.74	16.63	4.5
I-section grevillea	39,921.75	119.63	68.55	0.67	6.53	49.34	4.99
I-section eucalyptus	68,081.67	151.47	40.78	0.29	63.47	**63.78**	3.94

Table 3.1 Summary of Mechanical Properties of Timber Samples

gesting greater strength and making it preferable for load-bearing applications. Both species show similar compressive strengths, with eucalyptus at 30.92 N/mm² and grevillea at 30.59 N/mm². However, eucalyptus significantly surpasses grevillea in flexural strength, indicated by its Modulus of Rupture (MOR) of 23.09 N/mm² compared to grevillea's 16.17 N/mm², making it more suitable for resisting bending forces in structural elements like beams and joists. The Modulus of Elasticity (MOE) further emphasizes eucalyptus's advantages, as it is stiffer with a MOE of 6123.18 N/mm² versus grevillea's 4825.47 N/mm², indicating greater resistance to deformation under load. Eucalyptus also exhibits higher hardness (4.04 N) compared to grevillea (2.56 N), enhancing its durability for frequently used surfaces. In shear strength, eucalyptus outperforms grevillea (22.00 MPa vs. 18.65 MPa), underscoring its suitability for applications with significant shear forces, such as connections and joints. Despite these strengths, both species have high moisture content (20.16% for eucalyptus and 17.39% for grevillea), which can adversely affect mechanical properties and dimensional stability, highlighting the importance of effective drying and treatment processes.

4.2.2 Shear Properties in Standard Block CLT Panels

The shear strength values for both Grevillea and Eucalyptus are notably lower than their Modulus of Elasticity (MOE), Modulus of Rupture (MOR), and compressive strength, indicating a relative weakness in resisting shear forces despite their strengths in bending, stiffness, and compression. Specifically, Block CLT Eucalyptus has a shear strength of 16.63 MPa, while Block CLT Grevillea shows a strength of 14.02 MPa. Eucalyptus's shear strength is approximately 29.33% higher than that of Grevillea, making it a better choice for applications where shear resistance is critical. However, the lower shear strength of these CLT panels necessitates careful consideration in engineering applications, particularly in areas where shear forces are predominant. This may involve using alternative materials with higher shear resistance to maintain structural integrity. Engineers must design structures with these shear properties in mind, ensuring that CLT panels are configured to minimize exposure to excessive shear forces. Although both Grevillea and Eucalyptus CLT panels exhibit strong mechanical properties in stiffness, bending, and compression, their lower shear strength underscores the importance of careful consideration in structural applications.

4.2.3 Shear Strength in Custom I-Shaped Laminated Panels

The development of custom I-shaped laminated panels aimed to enhance mechanical properties beyond those achievable with standard block configurations. The evaluation of these custom panels revealed significant improvements in shear properties. The I-shaped laminated panels demonstrated remarkable shear strength compared to their standard block counterparts. I-Section Eucalyptus exhibited a shear strength of 36.78 MPa, while I-Section Grevillea showed 34.34 MPa shear strength. When compared to the standard Block CLT panels, the shear strength of I-Section panels significantly increased, as detailed in Table 4.2.

Table 4.2: Percentage increase Shear strength

Shear strength (Mpa)	Block CLT	I-Section	% increase
Grevillea	14.02	34.34	144.96%
Eucalyptus	16.63	36.78	121.14%

The substantial improvement highlights the effectiveness of the I-shaped design in enhancing the shear properties of CLT panels. The I-shaped configuration likely provides better distribution of shear forces and improved resistance to sliding failures, making it an excellent choice for applications demanding higher shear performance.

Figure 4.2: Shear strength of Block CLT and I-Section

As illustrated in Figure 4.2, I-sections exhibit higher shear strength compared to ordinary block configurations due to their optimized

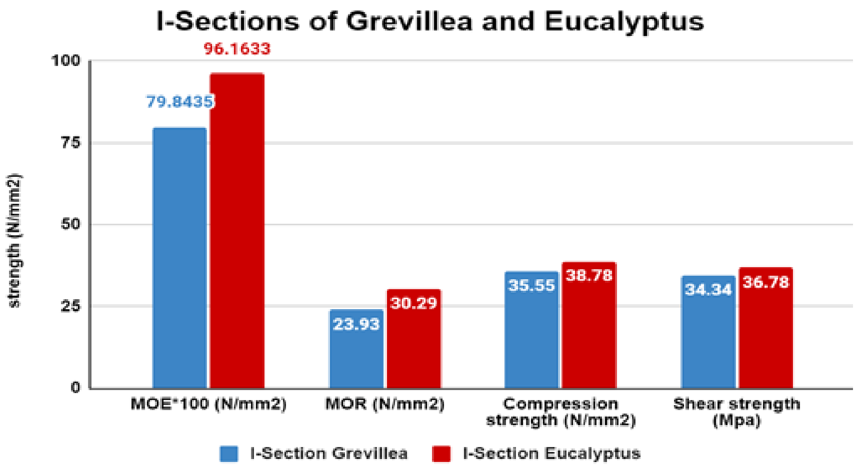
Property	Comparison
MOE	Eucalyptus is 20.46% better
MOR	Eucalyptus is 26.61% better
Compression Strength	Eucalyptus is 9.11% better
Density	Eucalyptus is 14.81% denser
Moisture Content	Eucalyptus has 15.92% higher moisture content
Shear Strength	Eucalyptus is 7.1% better
Average Hardness	Grevillea is 26.58% harder

Table 4.3: Comparison of Eucalyptus and Grevillea I-Sections

structural design. The geometry of the I-section significantly increases the moment of inertia, efficiently distributing material away from the neutral axis to enhance overall strength and stiffness. The I-shape effectively places material where it is most needed, providing greater resistance to shear and bending forces with minimal material use. The horizontal flanges at the top and bottom of the I-section resist bending moments and distribute loads more evenly, while the vertical web connects the flanges and handles shear stress. This design ensures even load distribution, reducing stress concentrations and the risk of shear failure. In conclusion, I-sections offer a higher strength-to-weight ratio, supporting more load without a proportional increase in material usage, thereby enhancing structural efficiency and stability. The I-section's design inherently provides higher shear strength due to its optimized geometry, efficient material distribution, and ability to distribute loads evenly. These factors contribute to the enhanced structural performance of I-sections compared to ordinary block configurations.

4.2.4 Comparing the Structural Performance of Eucalyptus and Grevillea Wood Species in Custom I-Shaped Engineered Timber Panels

The structural performance analysis, as shown in Table 4.3 and Figure 4.3, indicates that I-Section Eucalyptus panels outperformed I-Section Grevillea panels in key areas. Eucalyptus exhibited a 20.46% higher Modulus of Elasticity (MOE) (96.16 N/mm²) and a 26.61% superior Modulus of Rupture (MOR) (30.29 N/mm²), highlighting its increased stiffness and load-bearing capacity. This enhanced perfor-



mance can be attributed to Eucalyptus's denser cellular structure, which typically contributes to greater strength and rigidity compared to Grevillea. Eucalyptus demonstrated a 7.1% greater shear strength (36.78 MPa) compared to Grevillea (34.34 MPa), indicating better resistance to sliding forces. However, Eucalyptus had a 15.92% higher moisture content (20.16% vs. 17.39%), which may affect its mechanical properties in moisture-sensitive applications. In contrast, Grevillea excelled in compression strength, showing 9.11% higher strength (35.55 N/mm² vs. 38.78 N/mm² for Eucalyptus), and was 26.58% harder (4.99 compared to 3.94). While Eucalyptus is denser (0.62 g/cm³ vs. 0.54 g/cm³ for Grevillea).

Table 4.3: Comparison of Eucalyptus and Grevillea I-Sections

Property	Comparison
MOE	Eucalyptus is 20.46% better
MOR	Eucalyptus is 26.61% better
Compression Strength	Eucalyptus is 9.11% better
Density	Eucalyptus is 14.81% denser
Moisture Content	Eucalyptus has 15.92% higher moisture content
Shear Strength	Eucalyptus is 7.1% better
Average Hardness	Grevillea is 26.58% harder

Figure 4. 3: Performance of the Specimens' I-Sections

As shown in Figure 4.8, the comparison between the two wood species in I-section panels reveals that while Eucalyptus excels in stiffness, load-bearing capacity, and shear strength, Grevillea exhibits better compression strength, hardness, and a lower moisture content. These characteristics make each wood species suitable for different structural applications depending on the specific mechanical properties required for the design.

5. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusion

1. Material Suitability: Eucalyptus demonstrates superior mechanical properties such as higher MOE, MOR, and shear strength, making it well-suited for structural applications requiring stiffness and load-bearing capacity. Grevillea, with its higher compression strength and hardness, offers advantages in specific construction scenarios.

2. Shear Challenges: Standard block CLT panels, whether Eucalyptus or Grevillea, exhibit lower shear strength relative to their other mechanical properties. This highlights the need for careful engineering consideration to mitigate potential weaknesses in shear resistance.

3. Advancements with I-Sections: Custom I-shaped laminated panels significantly enhance shear strength compared to standard block configurations. The I-section design optimizes material distribution and load-bearing efficiency, offering improved structural performance and stability under complex loading conditions.

5.2 Recommendations

5.2.1 Recommendations from this Study

1. Enhance Treatment Processes: Improve methods for treating Eucalyptus and Grevillea timbers to optimize moisture content and density.

2.Assess the feasibility of using custom I-shaped laminated panels in construction to leverage their mechanical advantages.

3. Work with industry stakeholders to create standardized guidelines for Cross-Laminated Timber (CLT) use in structural applications.

4. Set up programs to monitor the durability and resilience of CLT structures in real-world conditions.

5.2.2 Recommendations for Further Study

1. Investigate the fire resistance of CLT panels made from various timber species.
2. Explore modern manufacturing techniques for CLT production to enhance efficiency.
3. Study the sound insulation capabilities of Eucalyptus and Grevillea CLT panels in building applications.

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Exploring Ceramic Materials and their Applications

By EiK correspondence

Ceramic materials are among the materials widely used in the different spheres of engineering.

They span a wide variety of applications among an equally diverse range of industries. With their heat resistance, electrical insulation, chemical inertness among a string of other unique properties they boast, ceramic materials make for ideal working material in several spaces.

Biomedical Engineering

Biomedical engineering Is a fusion of biological sciences and engineering merged in order to develop novel solutions in the healthcare space. Biomedical engineering heavily relies on the usage of ceramic materials in making orthopedic and dental implants as well as synthetic substitutes of bone grafts. Ceramic materials are predominantly the ideal choice due to their wear-resistance and general compatibility with body tissues.

Electrical Engineering

Ceramic materials are just as useful in the electrical engineering space. Materials such as alumina and barium titanate are preferred, largely due to their thermal conductivity which makes them a perfect fit for electric insulation. Ceramic materials are critical in the making of capacitors, resistors, and insulators that are installed in circuit boards, among others.

Architecture and Construction

One of the most common applications of ceramic materials is in architecture and construction. In fact, this field records some of the earliest applications of ceramic materials dating all the way back to circa 7000 BCE in Mesopotamia. Clay-based ceramics such as tiles and bricks commonly feature in construction. They are highly preferable due to their waterproof and durability properties as well as the fact that they are aesthetically pleasing. Architecture and construction largely use glass for countertops and windows. Still in this industry, architects and construction professionals use ceramic fiber to help with fireproofing and thermal insulation.

Aerospace

In aerospace, yttria-stabilized zirconia (YSZ), a ceramic oxide material, is used to create a thermal barrier coating (TBC) for such engine components as turbine blades and combustion chambers. These engine components are designed in such a way that they are constantly exposed to very high temperatures, and the YSZ coating protects the metal parts from heat damage. Thermal protection ensures longevity and is ultimately cost-savi in terms of maintenance. YSZ also makes for a tremendous electrolyte material for solid oxide fuel cells (SOFCs) that are often used in Auxiliary Power Units (APUs) of aircraft. Its suitability comes from its ability to facilitate efficient conversion of chemical energy into electrical power at extremely high temperatures through oxidation. Using it in APUs helps generate cleaner energy, which then reduces harmful emissions into the environment when aircraft are in use.

Automotive Industry

The automotive industry has also been benefitting greatly from the application of ceramic materials like zirconia, alumina, and silicon nitride. Zirconia is ideal for exhaust components and oxygen sensors, thanks to its ability to conduct ions as well as its chemical resistance. Alumina, on the other hand, is mostly used in spark plugs because of its thermal shock resistance. The lightweight nature of silicon coupled with its ability to withstand high-speed movements within the engine makes a preferred choice for making turbocharger rotors. Refractories is another fairly common application of ceramics. A refractory is a ceramic material that is designed with the ability to withstand very high temperatures, which are often found in manufacturing environments. Generally, there are two kinds of refractories; refractory ceramic fibers and preformed shapes.

They are made from both synthetic and natural materials, which can either be purely nonmetallic, or a healthy mix of various substances, for example bauxite, magnesite, and zirconia. Owing to their high heat resistance, these materials act as insulators that line the hot surfaces of industrial machines. Additionally, they remain inert in such high-temperature environments and are, therefore, incapable of interacting with the components they come into contact with.

Ceramic materials have several applications in various industries, some of which date as far as records go. Their high strength, heat resistance, and corrosion resistance among other properties make them indispensable in different processes across these industries. There is little doubt they will always be relevant even in future applications as technology keeps advancing

Prof. (Eng) Siphila Wanjiku Mumenya, Dean, Faculty of Engineering, University of Nairobi (UoN)

Fibre Reinforced Concrete in Modern Engineering

Introduction

Fiber Reinforced Concrete (FRC) is a type of fine-grained concrete consisting or mortar that incorporates fibrous materials to increase its structural integrity. These fibres can be made from steel, glass, synthetic materials (like polypropylene), or natural materials. These fibres are uniformly distributed and randomly oriented within the concrete matrix. Fiber Reinforced Concrete enhances the performance characteristics of conventional concrete, particularly under tensile and impact loading conditions.

Fiber Reinforced Concrete differs from conventional concrete in that the latter is a composite of only concrete matrix reinforced with steel bars at the macro level.

Benefits and limitations of fiber reinforced concrete

While FRC offers many advantages, namely, enhanced toughness and ductility, enhanced durability, and crack resistance, it also comes with certain limitations when compared to conventional concrete. FRC's limitations in workability, cost, and standardization may restrict its use unless specific performance benefits are required. In addition, while fibres improve tensile and post-crack behavior, they do not significantly increase compressive strength, which is often the primary load-bearing property in structural concrete. Surface finishing (e.g. troweling) can be difficult, especially with steel or synthetic fibres protruding. Pumping fiber concrete can be problematic due to blockages or uneven fiber dispersion. Also, if steel fibres are used and are exposed at the surface, they may corrode, affecting appearance and possibly durability in aggressive environments.

Contribution by academia

The Faculty of Engineering at the University of Nairobi (UoN) is actively contributing to research and innovation in advanced materials, including Fiber Reinforced Concrete (FRC), through various initiatives:

Research on Sisal Fiber Reinforced Concrete
In 1993, a study by Joackim M. Mutua examined the mechanical properties of sisal fiber reinforced concrete. The research demonstrated that sisal fibres can enhance the flexural and tensile strength of concrete, as well as improve toughness and interfacial bond strength. The study also explored the effects of fiber alignment and volume fractions on the material's performance.

Carbon Fiber Reinforced Polymer (CFRP) for Structural Retrofitting
A 2021 master's thesis by Muthomi Munyua investigated the use of CFRP wraps to strengthen non-slender square concrete columns. The study found that CFRP confinement significantly improved both axial capacity and ductility, especially in lower-grade concrete. The research also highlighted the efficiency of partial CFRP confinement compared to full confinement, offering insights for retrofitting existing structures.

International Engineering Conferences

The Faculty of Engineering organizes events like the 5th International Engineering Conference, which focuses on harnessing research for resilience and sustainability. Such platforms facilitate the exchange of knowledge on advanced materials and encourage interdisciplinary collaboration.

Innovation and Entrepreneurship Initiatives

Through the African Engineering and Technology Network (AFRETEC), UoN promotes entrepreneurship and innovation. Programs like the Innovation Fellowship Programme and startup incubators support students and staff in developing and commercializing innovative solutions, including those related to advanced materials.

These efforts underscore the University of Nairobi's commitment to advancing research and innovation in advanced materials, contributing to the development of sustainable and resilient infrastructure.

Academia-Industry collaboration

Academia and industry can collaborate in several impactful ways to scale the adoption of innovative materials like Fiber Reinforced Concrete (FRC) in the local construction sector. Some practical examples are: (i) joint research and development (R&D) projects; (ii) pilot projects and demonstration sites; (iii) curriculum alignment and industry training; (iv) material testing and certification partnerships; (v) innovation hubs and incubators; (vi) policy advocacy and standards development.

Practical applications of FRC

The University of Nairobi (UoN) is actively engaged in several groundbreaking research projects and practical applications that address pressing challenges in Kenya and across Africa. Some notable initiatives are: (i) climate resilient materials and infrastructure; (ii) sustainable construction; (iii) Artificial Intelligence (AI) and Innovation (iv) Green Building Practices.

These initiatives reflect UoN's commitment to addressing critical issues such as climate adaptation, urban-rural integration, technological innovation, and sustainable construction through research and practical applications.

Advise for early career researchers

For engineering students or researchers keen on specializing in materials engineering and particularly Fiber-Reinforced Composites (FRCs), they would be advised to build a strong foundation in Materials Science, specialize early with purpose by choosing electives or research projects related to composite materials, nanomaterials, or smart materials. They would also be advised to have hands-on experience by focused industrial attachments. They would also be advised to embrace simulation and computational tools that would expose them to research and innovation.

An important advice to early career researchers would be to forge strong networks and collaborations, and at the same time join professional bodies, attend conferences, webinars, and competitions focused on materials and composites.

Students would be encouraged to pursue further studies or certifications with a focus on advanced composites or materials characterization.

Students are further encouraged to Stay Updated with Emerging Trends, and read journals like Composites Science and Technology, Materials Today, and Journal of Reinforced Plastics and Composites.

Reimagining Traditional Materials: The Role of Timber and Plastics in Kenya's Engineering Future

Prof. Eng. Duncan Onyango Mbuge

1. What makes timber and plastics critical materials in engineering today, and how has their use evolved in the Kenyan context?

The building industry relies heavily on timber for construction and for every house that is built several trees are cut. Therefore, sustainability is important to make sure that even as the timber is used, more trees are planted and alternative materials are sought. One such alternative is plastic. There is also fast growing, self-regenerating trees like bamboo which can be used to make different types of boards and panels.

2. How is the University of Nairobi contributing to research and innovation in sustainable applications of timber and plastics in construction and manufacturing?

Research in timber and plastics at the University of Nairobi is approached from different perspectives depending on the department from which it is carried out. For instance, in Agriculture and forestry the growth characteristics of trees are analyzed and documented as well agroforestry. In Civil Engineering, the strength of timber is investigated for different indigenous species and new processing techniques are innovated. Other research interest include research in to the re-use of timber used as construction scaffolds, overcoming the round, hollow and nodal nature of bamboo to increase their application in construction.

For plastics the research interests include the use of recycled plastic for manufacture of plastic poles, porous pavements and for the manufacture of a wide range of plastic building components.

Unfortunately, most of the research is done is silos at departmental level and there is no coordinated programme that would result in a comprehensive policy in this subject.

3. Can you share any notable examples or case studies where engineered timber or recycled plastics have been successfully applied in local projects?

There are several companies in Kenya that are engaged in manufacture of particle boards and plastic poles at a commercial level. For example, Timsales is a wood-based industrial complex which manufactures plywood, fiberboards, block boards, flush doors and timber.

4. With the global push for sustainability, how do timber and plastics align with the circular economy and eco-conscious engineering practices?

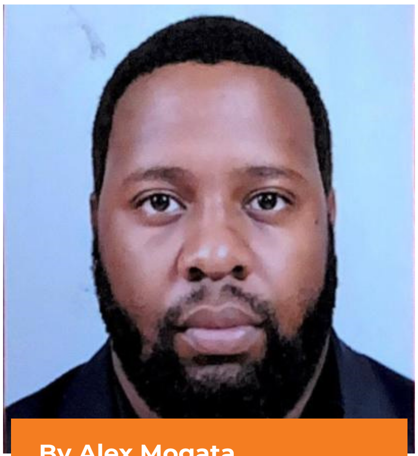
Timber and plastics are definitely recyclable, reusable and their use can be reduced as has been proved by different companies in this sector. Through research and innovation, the best practices to achieve circular economy principles are well documented.

5. What advice would you offer to those in the industry interested in material innovation, particularly in the fields of timber and polymer engineering?

They should work closely with universities by formally bringing their challenges to these institutions for research and innovation.

Prof. (Eng) Duncan Onyango Mbuge is the Associate Dean, Faculty of Engineering and an Associate Professor in the Department of Environmental and Biosystems Engineering, University of Nairobi. He is registered by the Engineers Board of Kenya (EBK) as a professional engineer and is a corporate member of the Institution of Engineers of Kenya (IEK). He is an Environmental Impact Assessment (EIA) Lead Expert. He is currently conducting research in renewable energy, food and process engineering, application of materials is agriculture, rainwater management technologies, low-cost machinery development, renewable energy especially biogas, development and promotion of solar thermal and PV systems for cooking, irrigation and lighting. In all these initiatives, I have participated in project management, as technical lead, participated actively in Monitoring, Evaluation and Learning (MEL) as a team member and I am also keen on Gender Equality, Disability and Social Inclusion (GEDSI).

KEBS' role in advancing Materials Engineering standards



By Alex Mogata
Manager, Civil and Electrical Engineering
Kenya Bureau of Standards

Q1: Could you start by briefly telling us about the core roles of KEBS and how they relate specifically to construction materials?

As an institution, we have three core roles: one is standardization (achieved through standard development), second is conformity assessments, third one is metrology services (achieved through calibration and testing), All these roles are interconnected; one cannot do without the other.

Specifically, regarding construction materials, we have a departments dedicated to testing and standardizing these materials. This involves:

i. Developing standards for both existing and new construction materials. This can be done either through local standard development or by adopting international best practices.

ii. Once standards are in place, we implement them through certification. This process involves rigorous inspection of quality controls, testing the manufactured products against set standards and ensuring compliance.

iii. Our core business in Quality assurance is conformity assessment. We work closely with both local and international manufacturers of construction materials to ensure their products meet the required standards.

iv. We also take part in the technical committees that develop these standards and actively participate in the testing process of materials sampled.

Q2: With the growing emphasis on sustainability, specifically towards the environmental aspect of it, how are you supporting the integration of eco-friendly and innovative construction materials?

First, for certification processes, we don't limit our certification to existing standards. We are open to new developments and innovations. When a manufacturer comes up with a new product, either construction-related or food-related, and there is no standard, there's a team that first sits with the manufacturer, goes through your production process and the manufacturers comes up with something called the customer specification. This is tailored to the specific product being manufactured.

That is however done after KEBS has ensured that there are no existing standards available for that product. The choice of standards to be used is dictated by the hierarchy of standards. This entails first checking for availability of an East African standard. If not, we look for a Kenyan standard. If not available, we look for an ISO standard. If that too is not available, we look for country standard if not we look for a workshop agreement. And if none of those are available, we revert back to the manufacturer to give us their customer specifications. Once we get the specifications, the committee adopts the specifications to create a standard based on the nature of the product.

We also offer what we call incubation services for new SMEs and new technologies, where we take you through the certification process, walk you through the quality controls that are supposed to be done, guide you through testing—how to do it—and then once you're ready, we absorb you and put you through our standard certification process.

We are trying to amend some of the standards to give room for certain products. For example, we are in the process of adopting an eco-friendly cement standard that reduces CO_2emissions by about 60%. We've also come up with a standard for recycling plastic products to make poles and blocks. And we are in the process of developing a standard for plastic electric power lines to reduce deforestation. We try as much as possible to incorporate standards and certification into the eco-friendly system. The only way to encourage people to go green is to give them an avenue through standard endorsements that support it.

Q3: How is KEBS strengthening market surveillance and enforcement to protect consumers and professionals in the construction industry?

There are three categories: non-conforming materials, substandard materials, and counterfeit materials.

Counterfeit materials fall under the jurisdiction of the Anti-Counterfeit Authority (ACA). When we come across such cases, we refer them to ACA for further action.

Substandard and non-conforming materials, however, are our focus at KEBS, especially with regard to quality assurance.

We ensure that all products released to the market meet the minimum quality threshold. We have put in stringent checks to ensure surveillance is carried out at all points.

From certification—which involves inspection, testing, and reviewing quality controls—we carry out mandatory surveillance randomly at factory level, to verify continued compliance. We also do random market surveillance and inspect outlets to confirm that what's being sold is what was certified.

Each of these steps has a team mandated to enforce within the two-year certification cycle. Within two years, we visit the factory at least twice. We also inspect outlets and construction sites.

We also empower users. Our website has a database where one can key in a permit number to see details about the manufacturer and product. On request, users can access test reports. We also have an anonymous reporting system, where anyone can flag suspicious or underperforming products, and we'll follow up with full investigations, including factory-level tracing.

Q4: To position ourselves better in the region and harmonize standards, especially for construction materials, what role is KEBS playing in regional and international alignment?

At KEBS, our vision is to become a global leader in standards-based solutions for trade and sustainable development. To achieve this, we're guided by strategic goals that focus on: Standards development, provision of technical services and trade facilitation.

We are actively engaged in regional and international standards organizations, including:

ISO (International Organization for Standardization), IEC (International Electrotechnical Commission) and the EAC (East African Community).

A key part of our strategy is working through the EAS – East African Standards framework. This enables us to harmonize standards across East Africa, so that products manufactured in Kenya, Uganda, Tanzania, and other member states all meet the same regional requirements.

However, harmonization does not mean blanket adoption of international standards. Some products are unique to Kenya's local context. When we review and adopt a standard at the East African level, we ensure that local conditions are reflected to protect and encourage local manufacturers. This means our standards must be globally aligned while also remaining locally practical.

Our legal foundation for this regional work is the EAC SQMT Act— framework for cooperation in Standardisation, Quality Assurance, Metrology and Testing in the EAC region framework ensures that the products manufactured in Kenya are competitive both regionally and globally, by adhering to internationally accepted quality and performance criteria.

Q5: How do you collaborate with professional bodies to support alignment with material standards and sustainability goals?

While we're still improving our frameworks, we actively engage with professional bodies to carry out awareness campaigns. For instance, we have an MoU with EBK.

The engineer on site takes responsibility for the quality of the building. So, we encourage them to verify certification and request performance test reports before use.

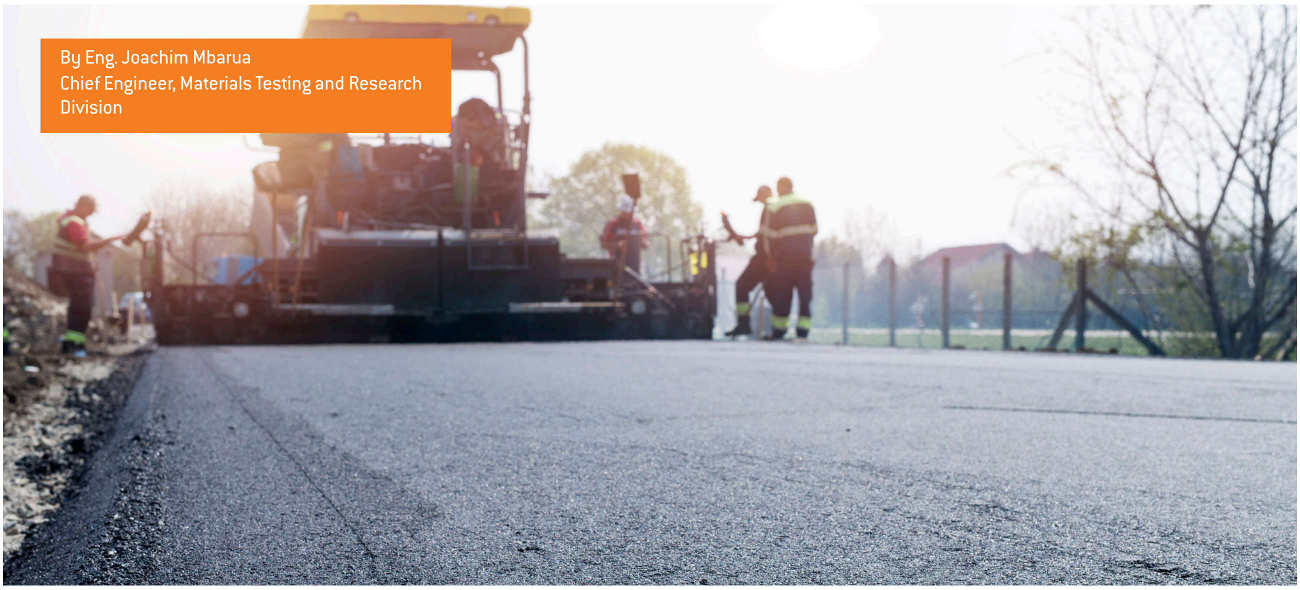
Some products like ready-mix concrete are consumed directly on-site. For such materials, which don't sit on shelves, the role of the engineer becomes even more vital. That's why we're advocating for a collaborative approach—a shared responsibility model—between KEBS, professional bodies, and engineers. When engineers verify quality and certification on their end, it creates a safer and more accountable construction environment.

Q6: Any final remarks?

First, thank you for this opportunity. Platforms like Engineering in Kenya magazine are crucial in helping us reach the wider engineering community and the public. They give us an avenue to share information, raise awareness, and strengthen collaboration.
We believe that by reaching the right audience, especially the technical professionals on the ground, we can enhance quality assurance and ultimately protect the public from substandard construction materials. This kind of engagement fosters shared responsibility. After all, I may be building today, you may be building tomorrow, and someone else the day after—so it's in all our interests to uphold standards.

The role of materials testing and research in shaping the future of roads and construction

By Eng. Joachim Mbarua
Chief Engineer, Materials Testing and Research Division



Materials Testing and Research Directorate (MTRD) was established back in the 1930s as a branch of the then Public Works Department and later became a Department under the Ministry of Works, Transport and Communications. Currently, MTRD is a Directorate under the Ministry of Roads and Transport and it is responsible for provision of testing services, research and advice on usage of construction materials for roads, bridges, buildings, and other critical infrastructure in Kenya and the Region.

Through the various transitions and designations, MTRD has continued to play a fundamental role in infrastructure development and supporting the Government's agenda for the realisation of Vision 2030. The importance of quality infrastructure cannot be overemphasized in enabling Kenya's Vision 2030, the Bottom-Up Economic Transformation Agenda (BETA), and the attainment of the Fourth Medium Term Plan (MTP IV) as it serves as a foundation for economic growth, inclusivity, and sustainability. Vision 2030, identifies robust infrastructure in transport, energy, ICT, and water as essential for enhancing connectivity, reducing business costs, and driving trade and industrialization while BETA emphasizes infrastructure as a tool for grassroots empowerment by improving access to markets and services in rural and marginalized areas, supporting small enterprises, and generating employment. On the other hand, MTP IV reinforces this by prioritizing climate-resilient, county-aligned, and productivity boosting infrastructure to accelerate national development. Materials Testing and Research Directorate whose motto is "Quality and Safety" helps these initiatives succeed by ensuring quality in construction methodologies and materials, hence maximizing return on investment and ensuring public safety.
Testing services for materials used in roads, housing, airports, water and health projects enables the delivery of quality public services, cost-effective and durable infrastructure thus supporting Kenya's socio-economic development. For roads, bridges and buildings, which are central to Kenya's take off, construction and construction materials must meet strict performance criteria. The Directorate offers laboratory and field-testing services for soils, gravels, aggregates, concrete, bituminous mixes, graded crushed stone, manufactured engineering and non-engineering materials and road marking materials; geotechnical surveys and foundation design; traffic surveys; pavement structural and surface condition surveys; non-destructive and destructive testing on bridges and buildings; pavement designs and advice on construction materials. Thus, informing the quality of infrastructure, impacting the durability and safety of projects, helping to prevent failures that could lead to loss of life and financial setbacks.

To achieve its objectives, the Directorate acquired modern state of the equipment including laser beam profilers, concrete pipe and precast elements testing machines, falling weight deflectometers, pavement friction testers, bitumen rheometer, Atomic Absorption Spectrophotometer (AAS) and Ground Penetrating Radar among others. Performance testing is carried out on materials and infrastructure to simulate real life conditions and select materials that withstand high stresses, extreme climatic conditions and other abnormal loading effects.

An offshoot function closely tied to the Directorate's work is the certification of construction materials. Materials certification involves a multi-step process, including laboratory testing, compliance checks, and performance evaluation. Materials that pass these assessments are certified as fit for use. This offers reassurance to developers, contractors, and the general public that the materials meet the established national and international standards. Certification guarantees quality in infrastructure projects, promotes safety, and boosts economic growth. It also ensures environmental sustainability by promoting eco-friendly building practices and materials. Ultimately, certification serves as both a quality checkpoint and a driver of innovation.

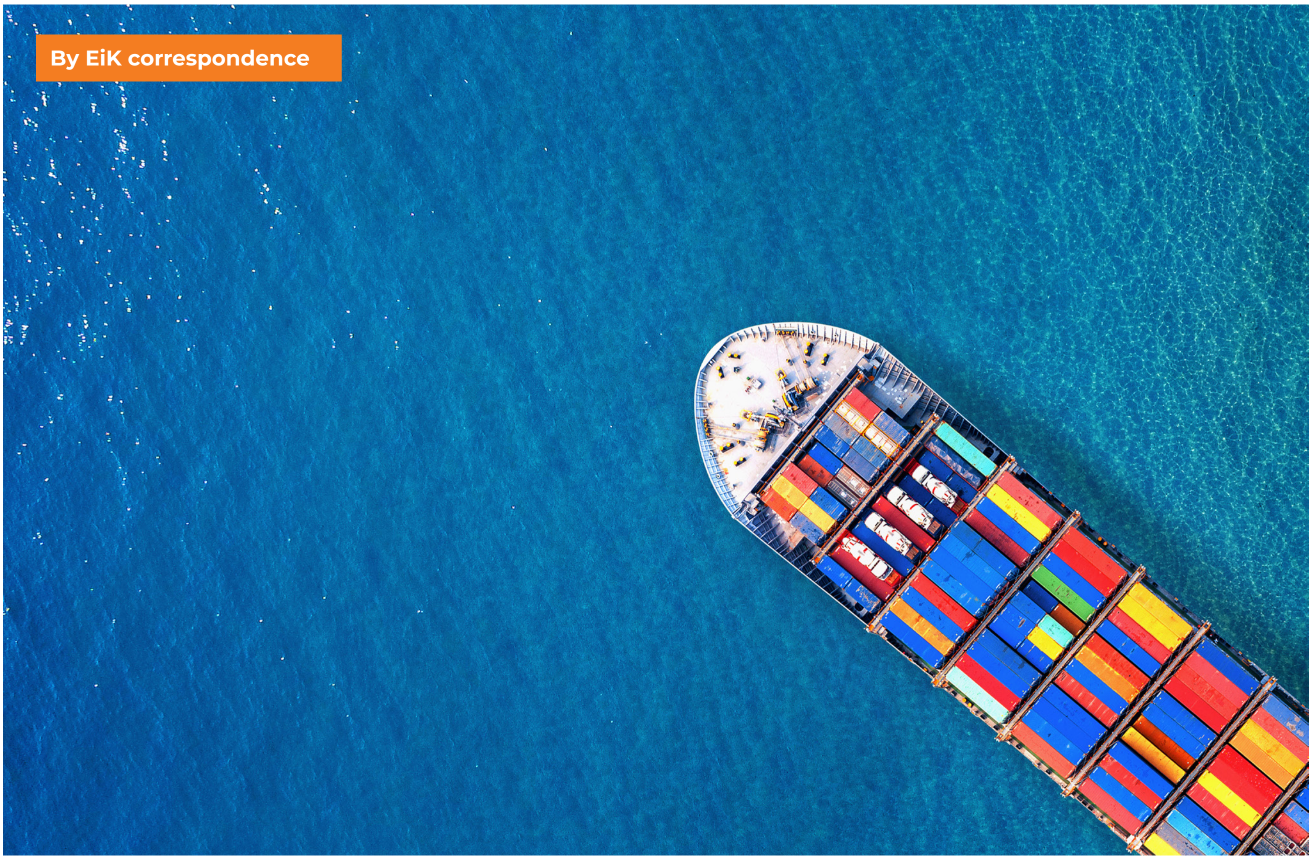
Research is carried out for identification of new materials, technologies and innovations suited to Kenya's environment. Under the Second Medium Term Plan (2013 – 2017), the Government aimed to increase the paved road network through construction of 10,000 km of Low Volume Sealed Roads (LVSR). The design and construction of the LVSRs was based on the Pavement Design Guideline for Low Volume Sealed Roads (PDG-1: 2017) which was an output of research findings and knowledge over the years under the Directorate. With Kenya's diverse climate from arid lands to coastal zones, materials must withstand varied weather and climatic conditions. Research and innovation on new construction materials such as geosynthetics, modified bitumen and alternative soil stabilizers are under consideration for their ability to enhance durability, reduce maintenance cost and improve project life spans. These studies also analyse project life-cycle costs, environmental impact and feasibility of locally available materials, for infrastructure that is both affordable, sustainable and climate friendly/resilient.
MTRD has digitized its Knowledge Resource Centre and put a Library and Information Management System (LIMS). Our data repository is informing the review of the almost complete road construction Manuals and Standards exercise.
Other Local Innovation and Industry Segment
Kenya's push for infrastructure development is also fuelled by the growing involvement of local industry players. These players are essential

in developing situation specific materials and introducing technologies that align with the Kenya's unique needs. These innovations include recycled plastic materials, alternative materials (of non-scrap value) for road signs and prefabricated drainage products.

Collaboration between the local innovators, government agencies, and research institutions enhances knowledge sharing and accelerates technological adoption. It also fosters a circular economy, where materials are reused and repurposed, reducing waste and supporting sustainability. The industry players also contribute to the standardization process, working closely with the Kenya Bureau of Standards (KEBS) and other bodies to ensure that their materials comply with regulatory frameworks. This cooperation strengthens the overall quality of infrastructure while supporting local economic development and job creation.

In conclusion, Materials Testing and Research Directorate's contribution supported by the certification systems and empowered by collaboration with the local industry, are key in the achievement of Kenya's infrastructure ambitions "from world-class highways to climate resilient housing". As Kenya advances towards a prosperous and resilient future, the significance of construction quality and materials will become increasingly vital, demonstrating that true progress is defined not only by what is built, but by how it is built.

How Global Trade Affects the Availability of Materials in Kenya



By EiK correspondence

According to the World Council of Civil Engineers President-elect Eng. Nathaniel Matalanga, Kenya has to pay special attention to local manufacturing if we are to achieve sustainability in the engineering field, and that creativity and innovation are our best bet to self-reliance. Materials engineering in Kenya is heavily reliant on imports. Kenya does export some materials and that earns us much needed foreign exchange, but the export volume is nothing compared to the import volume. While our involvement in global trade may have its perks, it may also have unfavorable impacts on the availability of materials in Kenya.

Global trade

Global trade refers to the exchange of goods and services across countries. Technological advances in communication have reduced the world to a global village, and now more than ever, it is easier to access, buy and sell goods and services in other countries. From the comfort of your home and with just access to the Internet, you can get in touch with an artisan in Vietnam, order your part and have it delivered within two weeks.
Things are however not that simple and clear cut when it comes to materials vital to the infrastructure of our country. Global trade is rooted on many determinant factors that may affect materials availability in Kenya both positively and negatively.

Why import materials at all?

A good world would be one where we can access raw materials from across the country, and have a good transport system that will ensure timely delivery to local manufacturing firms with highly skilled personnel who will transform it to quality finished products and sell it to consumer at favorable prices and everyone is happy.

But this not a good world and there are many reasons why materials have to be imported. While we have some raw materials like coal, iron and lime deposits, the production does not meet the local demand for steel, concrete and clinker. The manufacturing firms that produce these materials require robust investments as they are uniquely energy intensive.

Government policies and harsh economic environment drives up production costs that are passed on to the end consumer. This makes it cheaper to import materials. In some cases, our country simply does not have the raw materials needed for processing the required finished materials. All of these factors necessitate materials importation.
So how exactly does global trade affect the availability of materials in Kenya?

Import dependency

Due to the factors aforementioned, there is a marked dependency on imports of materials such as steel, aluminum, polymers, electronic components, and specialized alloys in Kenya. This chronic dependency adversely affects the availability of materials in the event of supply chain disruptions occasioned by unmitigated events such as pandemics and worker strikes in exporting countries.

The COVID-19 pandemic exposed just how deep Kenya's dependency to imports was, but it also revealed her capacity, especially through the private sector, to supply the local market with quality products. While this was a reaction in confinement, it shows that will the right support and policies and if the government trusts the private sector, they can supply quality materials and reduce the overreliance on imports.

Geopolitical tensions

Global trade is marred with geopolitical tensions that at best result in trade sanctions and punitive tariffs, and at worst spill over into full-blown wars. When this happens, disruption of the supply chain follows as trade routes shift, production lowers or halts altogether depending on the proximity to the conflict and material prices go up or the materials simply become unavailable.

Price volatility

Price volatility is a present reality in global trade, as global commodity markets influence material prices. When the demand for materials is so high in one region that supply is affected, the prices will go up. Kenya has been a casualty of currency fluctuations which also greatly affects the local pricing, and ultimately interferes with the availability of materials.
Delays in project timelines

The vagaries of global trade may result in delays in project timelines. Supply chain disruptions throw off project deadlines which may result in the projects stalling. Volatile prices of imported materials means that engineers have to constantly adjust project budgets which also interferes with project timelines if there is no fast reaction to these cost adjustments.

Custom materials notoriously have long lead times when they are sourced from distant markets. Not only do these factors disrupt project timelines, but they may also cause engineers to resort to alternative materials that may not adhere to the design integrity.

Local manufacturing

Overreliance on imported materials may discourage local manufacturing. The private sector may be willing to take produce materials locally, but they have to be assured of a ready market and they have to consider competition from the imported products. The road to self-reliance needs to be paved with better government policies that ensure a level playground for local manufacturers.

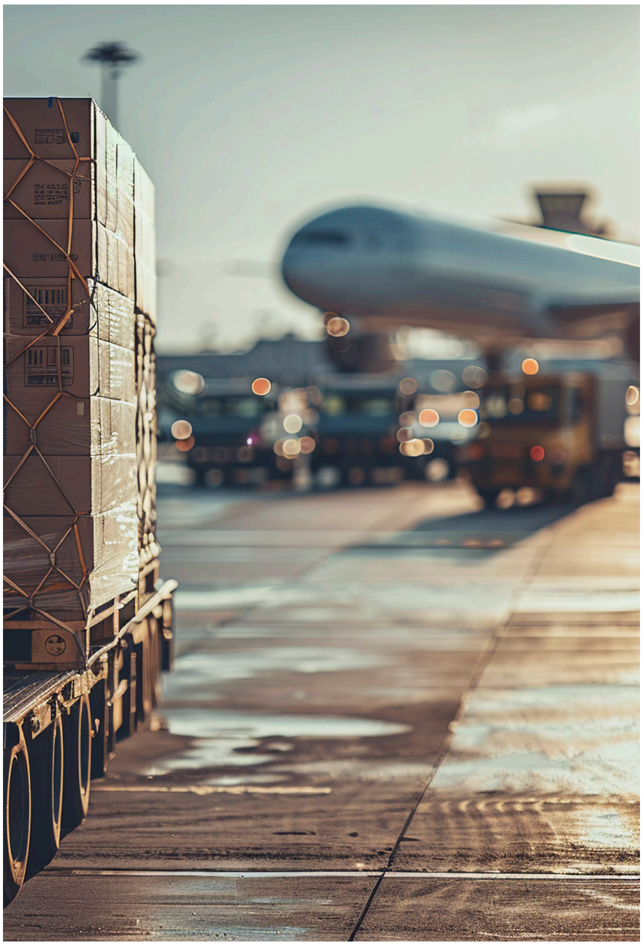
Innovation and local solutions

While global trade has its share of shortfalls as far as availability of materials is concerned, it has also opened the country to advanced materials which are not available locally but are still crucial to innovation.

Moreover, it has mandated the upskilling of local engineers who have to stay updated with international standards and applications for new materials.

Just as Eng. Matalanga posited, local creativity and innovation will be the backbone of sustainable engineering in Kenya, and that an engineer's calling is to find solutions to problems that may seem impossible. The scarcity and sometimes, unaffordability of imported materials can be innovatively overcome through the use of alternative materials or recycling methods.
It is especially difficult to achieve sustainability when all the cards are held offshore. Life Cycle Assessment, for instance, evaluates environmental impact from raw materials extraction to final disposal. When most of the materials have to come in and there is little to no information on the processes involved, it renders the assessment incomplete.

This is therefore a call to have local solutions to local problems by leveraging innovation because necessity still remains the mother of invention.



How new waterproofing is revolutionizing Kenyan construction

In the constantly changing world of construction, waterproofing was once an afterthought—a final item to be added to a contractor's list at the last minute. It has since become a cornerstone of climate-resilient, sustainable construction, particularly for Kenya's fast-growing cities. With mounting global environmental stresses, integrating waterproofing technologies with methane-mitigation methods is gaining momentum.

"It's no longer just about keeping water out of buildings," said Eng. Naomi Wambui, a senior architect with the Architectural Association of Kenya, during a recent panel at the Build Kenya Forum 2024. "We're now looking at materials that protect the structure, reduce energy use, and help us meet climate goals."

The green roof revolution

One of the most significant waterproofing developments has been the creation of green roofs, in which vegetative layers are installed over buildings, that need durable, water-tight systems under the ground. More than 30 commercial buildings in Nairobi alone have incorporated green roofs over the last two years, a 2023 report by the Kenya Green Building Society discovered.

Not only do these systems refrigerate our cities, they manage stormwater. Waterproofing membranes below them have to be high-performance and durable.

Materials that heal themselves

One of the most popular materials being used today in construction is self-healing concrete. Through its design incorporating embedded bacteria or polymer capsules, the concrete repairs itself prior to cracks becoming structural.

Though still in the early stages in Kenya, a pilot project launched in Machakos County in 2023 has shown promising results. "We've seen maintenance costs drop by almost 40% over 18 months in our pilot self-healing concrete project in Machakos," said Eng. James Odhiambo, materials specialist at the National Construction Authority, during the Sustainable Infrastructure and Materials Forum held in Nairobi in February 2024.

Methane: The silent threat beneath

While waterproofing keeps out moisture, there's another sneaky danger lurking underground—methane gas. With Nairobi's rapid growth, new housing developments are popping up on land that used to be industrial or even just plain old garbage dumps, where old organic material is decomposing.

A recent study in the East African Journal of Built Environment found that areas around some buildings in Ruai and Athi River have methane levels that are higher than normal. So, modern waterproofing systems are now being designed to act as barriers against methane too, especially in commercial zones. This is super important because it keeps gas from seeping into buildings, which can be a health hazard.

Merging solutions

The combination of methane mitigation and waterproofing is really gaining traction across East Africa. For example, in 2024, a new housing project in Naivasha started using vapor intrusion barriers—those are membranes that block both water and gas—after detecting methane hotspots during a site survey.

"Designing for gas and moisture intrusion together makes sense, especially when building on brownfield sites," said Eng. Miriam Kimani, a civil engineer with the Kenya Urban Roads Authority (KURA).

The future is thin, but mighty

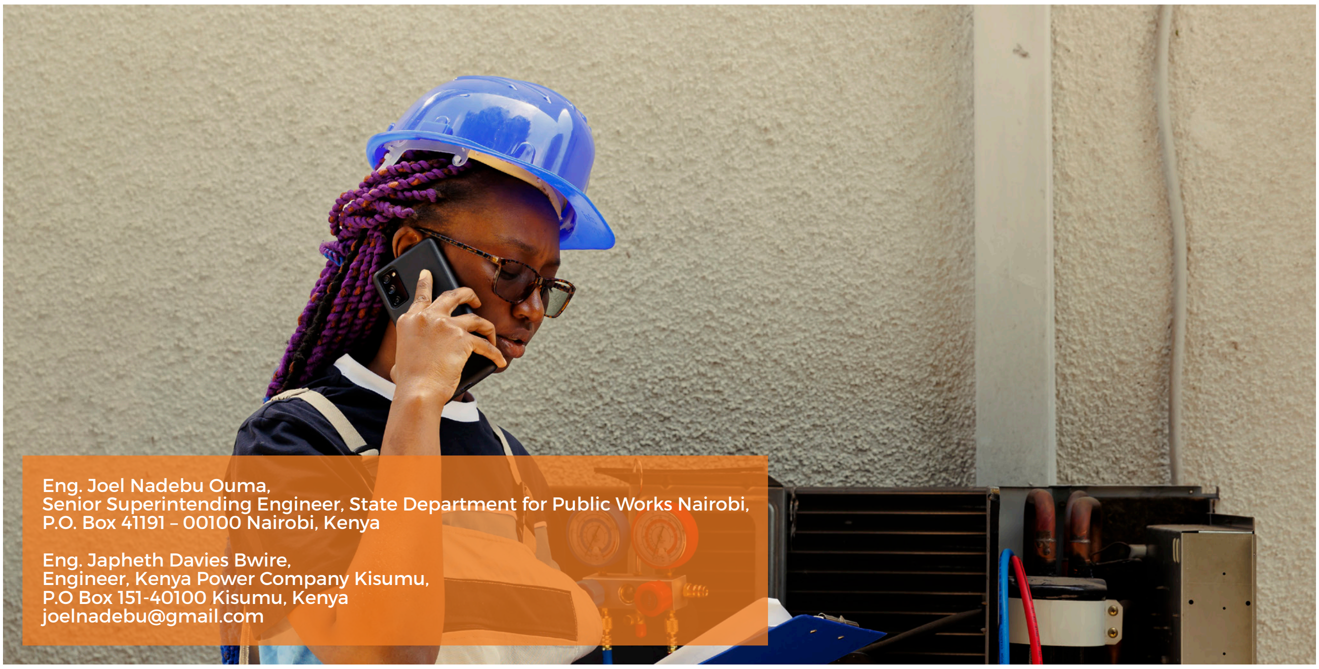
Nanotechnology is also revolutionizing waterproofing in the background. Nano-coatings, already implemented to protect Mombasa's ancient buildings, are an unseen, breathable armor that creates ultra-thin hydrophobic films. They have been applauded for not changing a building's appearance while protecting it.

Meanwhile, liquid-applied membranes, favored for their ease of application and adaptability to complex structures, are now standard in upscale developments in areas like Karen and Westlands.

Looking ahead

As Kenya strives to move towards climate-conscious construction, the blend of waterproofing innovations with methane mitigation strategies is likely to shift from being a nice-to-have to an absolute must-have.
With more than half of Nairobi's urban population expected to live in high-density areas by 2030, according to the Kenya National Bureau of Statistics, the demand for smart, layered protection systems against both water and gas is becoming really urgent. We've got to be ready!

Electrical Engineering Services in Built Environment - Opportunities for Electrical Engineers in the Affordable Housing Program



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Abstract

Cases of electrical shocks and accidents, some of whom are fatal, at residential and commercial buildings have been on the rise in the recent days. Similarly, inadequate implementation of electrical engineering services in Built environment has been witnessed over time and especially with the ever-dynamic technological advancements. Gaps in legal frameworks, inadequate capacity at regulatory agencies and lack of published records, unscrupulous business people, and aging structures among others are challenges leading to occurrences of electrical accidents and calamities in the built environment. The government's commitment towards addressing the housing shortage and prioritizing the agenda of setting up at least two hundred and fifty thousand affordable housing units annually is a key indicator that indeed electrical engineering practitioners will play a key role in the built environment. The sector's Kshs 35.2 Billion budgetary allocation in the financial year 2023/2024 according to National treasury will also open economic doors to unemployed engineers. The safety of the occupants of these houses as far as electrical engineering services is concerned can only be addressed by involvement of Electrical engineers in all the stages of the project. There is no doubt therefore, that the electrical engineering practitioners have various opportunities to be explored and to overcome the challenges that have been existing. This paper therefore aims at highlighting these opportunities and enlightening the need for Electrical Engineers to be actively involved in Built environment projects in all the phases.

Keywords: Affordable Housing, Built Environment, Electrical Engineering, Opportunities, Safety.

1. Introduction

Housing Agenda is one of the key pillars of the Government of Kenya's Bottom-up Economic Transformation Agenda (BETA) plan and is aligned to the Fourth Medium Term plan (MTP) of Kenya's vision 2030. The government of Kenya aims at delivering Two Hundred and Fifty affordable, low-cost housing units annually with a budgetary allocation of Kshs 35.5 billion. Additionally, the Housing agenda aims at creating over 100,000 jobs for youths including Engineers. This is a very great opportunity for the engineers to play their rightful roles in national prosperity and development. Key programs of the Housing Agenda include: Construction of markets, Construction of Housing units for National Police and Kenya Prisons, Kenya Urban Programme, Construction of Social Housing Units, Construction of affordable housing units and Mortgage facilities. [1]

Table 1: Distribution of 2023/2024budgetary allocations in Housing Agenda

Program	Allocation (Kshs)
Construction of Markets	5.1 Billion
Mortgage facilities	5.0 Billion
Construction of Affordable Housing Units	3.2 Billion
Kenya Informal Settlement Improvement Project – Phase II	5.6 Billion
Construction of Housing Units for National Police and Kenya Prisons	1.0 Billion
Kenyan Urban Program (KenUP);	7.2 Billion
Construction of Social Housing Units	3.3 Billion

Source: The National Treasury and Economic Planning- Financial year 2023/2024 Budget

The Housing agenda will achieve its objective with full inclusion and adoption of relevant electrical engineering services in the built environment. Efficient, safer, environmentally friendly and affordable electrical engineering services shall be adequately designed, installed, operated and maintained under the supervision of Electrical Engineers

A building without installation of electrical engineering service cannot be adequately used for residential, commercial, occupational, recreational or even health facility. These services make a building functional, efficient, and comfortable safer and secure livable. Unfortunately, some developers and builders opt for exclusion of Electrical engineers from their projects thus ending up with a risky electrical installation that is hazardous to the building itself and its occupants. This has led to electrical accident that

have been destructive to environment, property and to unfortunate extent fatal as recorded by the Energy and Petroleum Regulatory Authority (EPRA).
In the year 2020/2021, 65 out of 120 reported cases of electrical accidents and incidents were fatal whereas in 2019/2020 97 out of 133 reported cases were fatal. [2] More than 50% of these cases were in both financial years were caused by the following occurrences:

Table 2: Root causes of reported accidents in the years 2019/2020 and 2020/2021

	Period	
Cause of accident	2019/2020	2020/2021
Poor state of repair of the electricity distribution network.	25.6%	19%
Defective Consumer Installation	14.3%	12%
Illegal extension	12.0%	7%
Low awareness on electrical safety/Ignorance and Negligence	10.5%	6%
Unsafe work practices/work related	8.3%	11%
Proximity to power lines	3.8%	10%
Total for these causes	74.5%	65%

Source: Energy and Petroleum Regulatory Authority (EPRA) – Integrates Annual Report and Financial Statements for the years ended 30th June 2020 and 30th June 2021.

In view of the above data, it is evident that electrical accidents in Built environment are significantly high and this can be attributed to lack of adequate involvement of Electrical Engineers in development projects.

2. Overview of Electrical Engineering Services in Built environment.

The scope of electrical engineering services in the built environment have expanded over time due to demand for energy efficiency and conservations, aesthetics, safety and security, improved accessibility, Power backup systems, telecommunications services, automated solutions, building management systems, Artificial Intelligence among others. Electrical Engineers, with their enormous attributes of creativity, team player, problem solving skills, reliability, safety conscious, inquisitive among many more, have demonstrated the ability to tackle these demands thus enabling the client realize their dreams. This has been achieved through design calculation from first principles based on various factors which depend on building type, purpose, location and physical parameters. [3].

Figure 1: Electrical Engineering services in Built environment

3. Opportunities for Electrical Engineers in Built Environment- A case of government of Kenya advertised tenders.

Electrical Engineers are the prime movers in the global, regional and national quest towards full adoption of green energy and mitigation against climate change. The United Nations SDG goal 7 aims at ensuring access to affordable, reliable, sustainable and modern energy for all whereas SDG goal 13 aims at urgent action to combat climate change and its impact. The International Energy Agency (IEA) records that the built environment accounts for more than a third of global energy consumption and emissions through construction, cooling, heating, lighting as well as appliances and equipment. [4] IEA notes that incorporating right strategies could see buildings becoming 40% more energy efficient than today by the year 2040. [4] In the recently concluded Inaugural Africa Climate summit 2023 (ACS2023), African heads of state committed to building effective partnership between Africa and other regions, to meet the needs for financial, technical and technological support, and knowledge sharing for climate change adaptation as well as Promoting investments in urban infrastructure through upgrading informal settlements and slum areas to build climate resilient cities and urban centers. [5]

The involvement of Electrical Engineers in the affordable house not only does it ensure that the goals are realized but also ensures achievement of many other benefits such as: Reduction of GHG emissions and other environmental impacts, lower energy costs, increased employment opportunities and market enhancement, demonstrated leadership in public awareness of energy conservation, improved comfortability, Value addition to the projects among others.

The government through various MDAs has advertised opportunities under Housing agenda for electrical engineers though tenders. The categories of these tenders are:

Construction of Various Economic stimulus Program (ESP) markets in various counties; Proposed Development of fresh produce markets in various counties; Design, Build, Finance and Transfer of Housing Units and Associated Infrastructure for National Police service, Kenya Defense forces and in various counties; proposed construction of county aggregation and industrial parks in various counties. [6]. In these projects, the government has laid down terms of references that embrace green building adoption incorporating green energy supply, compliance with IFC EDGE minimum standards, robust future proof ICT systems, surveillance, fiber inter-connectivity to commercial and other dwellings, enhanced accessibility by elderly, differently enabled, vulnerable group among others. The element of efficiency and affordability during occupation and maintenance phase has also been greatly emphasized.

Despite the need for electrical engineering services in built environment and the massive rollout of infrastructural projects in Kenya, several gaps and impediments to full involvement of

Electrical Engineers in affordable housing projects have been noted.

An analysis of the advertised tenders revealed these gaps in documentation that include:
Designs, Specifications and Bills of quantities for Electrical Engineering services. Electrical Installation works and structured cabling works were provided for as provisional sum. Most of the projected had these provisional sums capped at One Million Kenya Shillings which is an under budgeting for these services considering the magnitude of the project and target groups. This implies that the opinion of Electrical Engineers was not sought for or was ignored during project design and documentation.

Qualification for Electrical subcontractor was not included in the tender evaluation criteria. This gives room for the contractor to avoid using right personnel in implementation of Electrical Installations works. The contractor may opt to involve inexperienced and semi-skilled personnel to in installing the electrical works.
Little or no emphasis to involvement of local personnel especially for turnkey projects. In the evaluation criteria, inclusion of local professionals was assigned a maximum of 1 mark only. This is a threat to the local professionals including electrical Engineers who may be replaced by foreigners whose credentials may not be known or they are not in touch with the local regulations in the built environment.

These gaps if not addressed in urgently may lead to deficiencies in design, implementation and maintenance of the noble projects.

4. Challenges faced in deployment of Electrical Engineering services in Built Environment.

The National Construction Authority (NCA) in its Research Study on Failure and collapse of buildings in the construction Industry in Kenya noted that there was a weak regulatory regime in electrical engineering sector in the built environment with most building construction lacking electrical designs prepared by a Professional electrical engineer thus not compliant with the building code. [7] It also noted high involvement of unskilled and uncertified personnel undertaking electrical installation works with faulty designs and use of substandard materials for electrical installation works. This is a clear indication that the Electrical Engineers are not fully involved in these projects and gives room for shortcuts by unscrupulous business people who are out to save or make money at the expense of electrical safety and energy efficiency. The record keeping and public awareness on Electrical engineering services in built environment is also wanting especially from the industry regulators.

5. Conclusion

The government's housing agenda provides a great opportunity for Kenyan Engineers to showcase their skills, creativity and expertise. The electrical engineering services in built environment plays a critical role towards safety, energy conservation, interconnectivity, accessibility, comfortability, affordability and economic growth. There is no doubt based on the data and reports available from regulatory bodies in built environment that there are projects being implemented without full and adequate involvement of Electrical engineers thus causing electrical accidents and incidences some of whom have led to loss of lives.

Electrical engineers' role in the successful deployment of built environment projects cannot be ignored considering the vast benefits they bring onboard as far as energy efficiency is concerned as well as safety, security, connectivity, automation and artificial intelligence is concerned. Despite the gas witnessed in the sampled government tenders above, there is still light at the end of the tunnel if all stakeholders can give this matter a collaborative approach for effective results.

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The Carbon Gap in Sustainable Housing and Infrastructure Development, A Lifecycle Approach for Climate Change and Adaptation in Developing Countries

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Abstract

According to the United Nations Environment Program UNEP report on Infrastructure for Climate Action 2021, infrastructure contributes to 79% of all greenhouse gas GHG emissions and accounts for 88% of all adaptation costs. According to the International Development Infrastructure Commission Recommendation Report, 2020, an outlay estimated at US$ 90 trillion is required for infrastructure development by developing and emerging countries for the period 2016-2030. Considering that carbon constitutes over 79% of GHG emissions, what volume of carbon emission is expected from housing and infrastructure developments in developing countries by 2030? How are the emissions being measured, tracked and or controlled nationally or at infrastructure project level? Developing countries have a huge deficit of the 17 United Nations Sustainable Development Goals (SDGs) yet to be implemented implying the largest Co2 emissions. Urgent policy framework and paradigm shift to less carbon-based solutions recommended at national and project level respectively. There is deficiency of data on expected carbon Co2/GHG emissions from planned and ongoing housing and infrastructure projects. Each project has a carbon footprint. Further, the type of construction, materials used, and volume of fuel consumed determines the level of carbon emissions. There is carbon contribution at each project milestone i.e., planning, commissioning, operations, and decommissioning. Use of carbon plan(s) with project life cycle (PLC) approach is an effective technique for estimation of expected carbon footprint and low emission strategy. The study explores and recommends a policy framework approach and application of carbon plans and project lifecycle model for infrastructure and building construction or development in Kenya as a climate change and adaptation.

Key Words: Carbon, Greenhouse Gas, Climate Change, Adaptation, Action, Lifecycle.

Introduction

The world today is faced with troubling issues of rising accumulation of greenhouse gases and consequent global warming (Tathagat and Dod, 2015). According to the Paris Agreement 2015, a target was established to reduce the global temperature rise at between 1.5ºC to 2ºC above pre-industrial levels by 2030. According to the International Development Infrastructure Commission Recommendation Report, 2020, an outlay estimated at US$ 90 trillion is required for infrastructure development by developing and emerging countries for the period 2016-2030. Further, the United Nations (UN) conference on trade and development estimated US$ 2.5 trillion to address the investment gap in developing countries including infrastructure needs annually to realize the global goals. Noting that each infrastructure and building construction has a carbon footprint, higher carbon or greenhouse gas GHG emissions are expected from developing countries. This applies if business as usual situation is sustained in engineering developments.

Beside Kenya being a signatory and obligated to the Paris Agreement 2015 and use of Kenya Carbon Emissions Reduction Tool (KCERT 2050) to establish optimal energy pathway to realize reduction in GHG emissions by 32%, there exists a gap in carbon and GHG emission management i.e., tracking, measurement, accounting and reporting at project or activity level in Kenya. The application of the KCERT2050 tool is only limited to modelling energy consumption and corresponding annual GHG or carbon emissions for policy considerations. The identified gap which is lack of mechanism to project, measure, track and account for carbon emissions in projects impacts sector level performance and reporting on carbon or GHG emissions. The study focused on construction sector where housing and infrastructure constructions are highest. Buildings are responsible for 35% of global energy consumption and 38% of global energy-related CO2 emissions (United Nation Environment Programme (UNEP), 2020). Kenya's carbon or GHG emission data is primarily collected from the operational or use phase of most projects implemented across various sectors. This is inadequate as it lacks life cycle carbon contribution. For green construction, project life cycle PLC approach with life cycle assessment LCA is commended for wholistic determination of carbon footprint (CF) [15]. The deficiency of data on carbon estimates at project determinative stages i.e., initiation, planning, design, approval, commissioning, decommissioning and disposal impedes emission control over the PLC

[1,8]. The LCA is beneficial to decision-making process in that it can be used to review sustainability initiatives throughout the entire life cycle of the infrastructure or building, including the design, detailing, delivery and disposal phases. A number of studies in North America, Europe and Japan used LCA as a useful tool for determining the carbon footprint and embodied energy consumption in assessing the environmental performance of buildings (Lemay, 2011, Bribián et al., 2009, Junnila and Horvath, 2003, Junnila et al., 2006, Suzuki and Oka, 1998). Various construction activities lead to environmental pollution through land clearing, equipment's engine emissions, demolition, burning, and use of dangerous chemicals, among others according to (Adebowale Philips Akinyemi et al., 2017). Lack of accurate accounting and tracking emissions as identified in the gap further risks loss of credit opportunities in carbon markets. Effective accounting of carbon emission requires continual evaluation of variances during the entire PLC comparing baseline estimates established at project initiation (planning) versus actual levels measured during construction, operation or use phase. Building construction accounts for an estimate 40% of global energy-related emissions.

The study used qualitative techniques and reviewed literature associated with reduction of carbon or GHG emissions in construction project with notable case study of buildings [2,3,4,5,6,8] and port construction [15]. The study recommends use of project life cycle PLC approach with incorporation of life cycle assessment (LCA) [2,3,6,8,13]. PLC assures effective projections of carbon or GHG emissions for project life cycle however LCA established embodied energy analysis and emissions for materials (with existing carbon values or coefficients) and components used at different stages of project life cycle [1]. Study findings to improve policy framework, adoption of carbon plans, and establish inventory for sustainable materials (carbon coefficients) etc. These will improve carbon or GHG management through introduction of carbon plans in project approval and funding as part of sustainability, accurate reporting on carbon or GHG emissions and projections, increased opportunities in carbon markets for infrastructure and housing projects by the Government of Kenya, public and private sector players and non-governmental institutions. Stakeholders in regulatory, standards and capacity building notably the Institution of Engineers of Kenya (IEK), the Engineers Board of Kenya (EBK) and Environment Institute of Kenya (EIK), ministries and other agencies etc. will use the findings to advance low emission strategies and capacity at sector and institutional levels for engineering development and success of NDC targets.

1.1 Carbon Quantifications

Carbon footprint is a measure of the exclusive total amount of carbon dioxide emission that is directly and indirectly caused by an activity or is accumulated over the life stages of a product, including activities of individuals, populations, governments, companies, organizations, processes, industrial sectors etc. (Wiedmann and Minx, 2008). Outstanding merit for CF calculation is that it is possible to adapt it to any project [15]. All sectors should be obliged to perform CF calculations for posterity more so construction sector whereby significant impact on the environment due to large earth movements, the treatment of compound materials, and land modification is prevalent. Globally, 20% of carbon and GHG emissions are generated by construction sector being the first in material(s) consumption. LCA methodology allows calculation, evaluation, and interpretation of the generated emissions during the lifetime of an infrastructure or building thereby showing the GHG produced during all the project phases [2,3,6,8,13]

1.2 Project Life Cycle (PLC) for Carbon Reduction in Construction Projects.

LCA allows the calculation, evaluation, and interpretation of the generated carbon emissions during the lifetime of an infrastructure, building thereby showing the GHG produced during all the project phases [2,3,6,8,13]. PLC acts to establish the start and end of a project [1]. The four stages in PLC are initiation or conceptualisation, planning or design, execution or implementation, and termination or closure [1]. Green and conventional projects are similar with one notable dissimilarity. Green construction model focuses on sustainability and environment friendly requirements unlike conventional. PLC requires low carbon emission or GHG strategies to be considered at the project initiation and concept stage [1]. These benefits are transferred inter-stage to the end of the project [1]. Each project stage in a green construction concept interrelates with the next for transfer of green benefits or low carbon gains [1]. It is expected that an accumulated gain of green benefits is realizable at the end of the PLC [1].

1.3 The Initiation phase/ Project Initiation

At this stage conceptualization or concept development incorporates low carbon planning. This impacts the design concept and whole series of construction activities to the project end of life [1]. The owner sets a green centric project strategy leading to green designs, shapes, technology, and construction. Green model influences the process(s) hence control project financing, team, cost, quality, and time [1]. The people qualifications include training on sustainability and or low emission. Stage deliverable(s) comprises documentation on tasks, responsibilities, project details (name, budget, appointments etc).

1.4 The Design Phase/ Project Planning

The most significant stage of PLC that projects expected carbon or GHG emissions associated with the gradual implementation of a projects [1]. Green drawings, designs and building specifications done for low carbon. Consultancy or expertise sourced for complex projects to avert risks of poor designs causing changes in project scope, and strategy, repetitive work, delays in schedule, and cost swelling [1]. Green centric design comprises two main aspects: (1) Life Cycle Assessment (LCA) and (2) Eco-Conscious Design (ECD) [1]. LCA is key in determination of embodied carbon hence critical for material selection [2,3,6,8,13]. Green centric planning stage assures deliverables that transfer benefits to construction stage in form of project structure and team, detailed design drawing(s), task scope(s), technical data, project schedules, work schedules, material / spending schedules, procedures, etc.

1.5 The Construction Phase/ Project Execution

Dependent on the deliverables from initiation, planning and design stage [1]. Major risks occur that change project scope at this stage notably force majeure, resource and finance constraints, contractual and stakeholder conflicts etc [1]. Key activities are supply of materials, construction methods, use of tools and labor, waste management and upkeep prior to handover. These influence emissions mainly choice of materials and transportation. Cradle to gate, cradle to site and cradle to handover processes apply in supply of materials for low emission objectives. Heavy equipment consumes fossil-derived oils hence higher footprint. Labour efficiency during construction activities determines carbon reduction as carbon is calculated on the activities of workers during the project. Waste management and residual cleaning of buildings and maintenance of buildings is the ultimate activity of the project life cycle [1]. Direct carbon-based wastes originate from the combustion process of material waste at the project site while indirect waste come from the process of transporting solid waste discharges to landfill sites. Research shows that construction industry produces large amounts of waste and more than 50% of the waste material is deposited in the final dump [1]. Nearly 26% of landfill sites are occupied by construction waste [1]. Quality and control are key at this stage of construction. Deliverables are project documentation i.e., reports comprising of change management, tests, inspections, risks and meetings.[1].

1.6 Project Handover/Closure/ Operational /Maintenance

Final examination of works in respect to the contractual scope is done upon completion of construction stage. Detailed checklists are used containing all items of work including pending item(s) capture in defects liability period. Once all corrective actions are effected, it is necessary to review all construction activities before the work is declared complete and handover to owner. The final inspection should involve all key stakeholder representatives. The final deliverable is documentation comprising all control documents in the construction phase, final drawing (as built drawing), and the operating manual and the handover report. Green construction concept requires an evaluation of carbon and GHG emissions is performed to account for variances in actual project emissions from projections at initiation.

1.7 Carbon Emission in Construction

Infrastructure and buildings constructions consume the largest volumes of materials. This makes them lead in carbon emissions due to high embodied energy in materials used. Embodied Energy corresponds to the energy expended by all processes associated with the production of building materials and their components. This includes mining, manufacturing materials and equipment, assembly and transportation etc. Therefore, total contained energy during construction of infrastructure and buildings is directly proportional to the level of complex material used and process(s) involved. In typical construction(s) highest emissions of CO2 arise from the use of concrete, aluminium and steel. These have high contained energy levels. This imply the contained energy is as an indicator of the overall environmental impact of building materials and systems. Carbon energy is the energy spent during the construction process. It is consequential energy from the manufacturing, distribution / supply, transportation and equipment used during construction work. Generally, it comes from combustion (fossils), such as in factories and vehicles. Embodied carbon is calculated by KgCO2 / Kg unit of material or based on its functional unit using kgCO2 / m3 of material or kgCO2 / m2 of material, where each material has different energy values.

Methodology

This study used qualitative methods Literature associated with reduction of carbon emission Literature on select cases associated with low carbon emission strategies were reviewed as follows building construction in Western Australia [4], Port Construction [15], Industrial Park in China [7], storey building Växjö, Sweden [8]. The study analyzed and divulged findings and interpretations of previous research on reduction of carbon emissions. The study attempted to categorize the content of the research into the project life cycle (PLC) scope. Grounded on this opinion, the formulation of research problems associated with carbon emission in relation to PLC drawn clearly.

The study adopted two steps to improve the quality and reliability of the literature review sources (Alwan et al., 2017). Firstly, using organized keywords in well-established and high-quality scientific journals and repositories. Key words were used to collect materials for the study. The study adopted two steps to improve the quality and reliability of the literature review sources (Alwan et al., 2017). Firstly, using organized keywords to collect information in well-established and high-quality scientific journals and repositories. Lastly the literature review of carbon emission reduction strategies from industry, Governments and international agency reports, Internet and media publications, etc. Further secondary data sources in the form of a literature review consisting of industry, Government and international agencies reports, internet and media publications, etc were used. Purposive sampling and descriptive analysis methods used in data collection however analysis and interpretation done by mapping each of the research topics of the journal in tabular form. Table 1 below comprise results of research journal mapping on carbon emission reduction strategy reviewed in PLC as below.

Results

Table 1. Research On Carbon Emission Decrease Strategies Reviewed in The Project Life Cycle (PLC).

Source: data.worldbank.org

It is deducible from figure 1(next page) that construction sector in Kenya had a growth rate of 17.7% in the year 2022. Construction industry in Kenya is expected to grow by 7.7% reaching KES 973 billion-in 2023[11]. The construction output in the country is projected at KES 1,279.1 billion by 2027[11].The industry is expected to register annual average growth rate of 5.7% from 2023 to 2026, supported by investments in transport, electricity, housing, and manufacturing [10] Additionally construction are 250,000

Reference	Year	Location	Type of Research/ Analysis	Type of Construction	Parameter Studied	Project Life Cycle – PLC			Case Study
						Init	Design	Const	
Pomponi & Moncaster	2016	-	LCA	Building	CO2	-	-	X	Construction
Atmaca & Atmaca	2015	Turkey	LCA (LCEA & LCCO2A)	Building	Energy & CO2	-	-	X	Building const, operation & Demolition
Baek et al.	2013	-	LCA (LCCO2)	Building	CO2	-	X	X	Design, Const, Operation, Disposal
Dong et al.	2013	SETDZ, China	Hybrid LCA	Industrial Park	CO2 / GHG	-	-	X	Operations
Pomponi & Moncaster.	2016	European Union-EU	LCA,	Building	CO2	-	X	X	Design, Const, Operation, Disposal
Biswas, 2014	2014	Western Australia	LCA	Building	CO2	-	X	X	Design, const, Operation, Disposal
Chou & Yeh	2015	-	LCA & Monte Carlo	Building	CO2	-	X	X	Design, const, Operation, Disposal
Gustavsson et al.	2010	Sweden	LCA & Bottom-up	Building	CO2	-	X	X	Construction

Table 1. Research On Carbon Emission Decrease Strategies Reviewed in The Project Life Cycle (PLC).

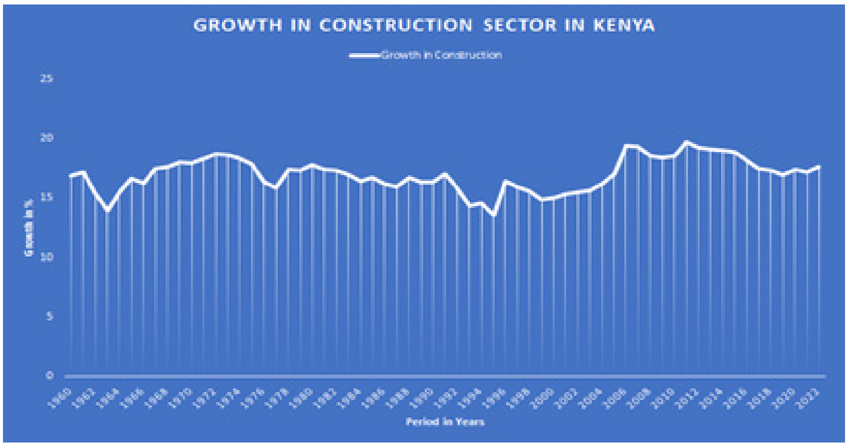

Figure 1: Growth in construction sector in Kenya period 1960 to 2022.

new affordable houses every year through PPPs, new 'level six' hospitals in six new sites, a 100,000km fiber optic connectivity network, and building a 700km road along the Kula, Isiolo, Mawe-Modogashe-Samatar-Wajir-Kutulo-El Wak-Ramu corridor, etc. [10]. All these constructions will increase the carbon footprint if business as usual scenario persists

Discussion

Table 1 below illustrates the literature-based review on carbon emission reduction relation to activity on the project life cycle PLC. From the 8 pieces of literature, researchers adopted the LCA method. A case of hybrid LCA as well as combinations of LCA with other analytical models noted i.e., Monte Carlo simulation, and Bottom-up analytical techniques. LCA is prevalent for analysis of embodied energy and consequent carbon emissions over a material, product or item lifecycle. This is useful for emission reduction strategies in construction noting most materials used emit variant levels of carbon dependent on embodied energy. It is noteworthy that PLC requires low carbon strategies be incorporated at the project initiation stage. The 8-research literature reviewed did not explicitly demonstrate in PLC activity.

Table 3 Summary of activities recommended under each stage of the PLC for low carbon model.

No Initiation Design Construction and handover

1. Stakeholder awareness for low carbon planning

Emphasis on low carbon designs with attention to optimizing the structure / building element. Optimize and go green procurement or green supply chain for faster acquisition of material and equipment distribution

2. Government facilitate dissemination of knowledge on low carbon strategies.

Prioritization of low carbon building materials. Reduction of emissions through machine optimisation and increased operator expertise.

3. Government and International institution establish environmentally sound building standards planning the building.

Design for ease of disassembly Best choice of construction method to increase efficiency in time, cost and material to have low waste generation.

4 Design concept to include use of renewable energy. Use of eco-labelled materials in every building component for carbon reduction
5. Use of PLC and LCA in selection of low carbon material i.e., cement, steel & ceramic important..

Optimisation of energy, electricity, gas and water and material utilization in every construction operational activity

6. More innovative low carbon designs.

Adoption of the concept of reduce, reuse and recycle in waste management.

7. Utilize new technologies and renewable energy for reduction of carbon emissions

8. Engineer building structures using green cement and utilize wood materials to further reduce carbon emissions
Source: Author, 2023

Conclusions

The Government has prioritized affordable housing and infrastructure development in Kenya. It is noteworthy that Kenya is a signatory to the Paris Agreement 2015 and hence obligated

No	Initiation	Design	Construction and handover
1	Stakeholder awareness for low carbon planning	Emphasis on low carbon designs with attention to optimizing the structure / building element.	Optimize and go green procurement or green supply chain for faster acquisition of material and equipment distribution
2	Government facilitate dissemination of knowledge on low carbon strategies.	Prioritization of low carbon building materials.	Reduction of emissions through machine optimisation and increased operator expertise.
3	Government and International institution establish environmentally sound building standards planning the building	Design for ease of disassembly	Best choice of construction method to increase efficiency in time, cost and material to have low waste generation.
4		Design concept to include use of renewable energy.	Use of eco-labelled materials in every building component for carbon reduction
5		Use of PLC and LCA in selection of low carbon material i.e., cement, steel & ceramic important.	Optimisation of energy, electricity, gas and water and material utilization in every construction operational activity
6		More innovative low carbon designs.	Adoption of the concept of reduce, reuse and recycle in waste management.
7			Utilize new technologies and renewable energy for reduction of carbon emissions
8			Engineer building structures using green cement and utilize wood materials to further reduce carbon emissions

through NDC to ambitiously achieve below 2C temperature rise by 2030. Each project regardless of scope has a carbon footprint. The carbon emissions reduction measures in the construction life cycle start from the initiation stage where the project owner has great authority in determining the whole series of construction activities [1]. The PLC approach ensures that putting forward the concept of low carbon in the initiation phase, the same is passed to successive stages of PLC herein low carbon design and further low carbon construction [1]. Therefore, the concept of low carbon will be developed on low carbon operational, low carbon dismantling and recycling following the life cycle of the building. In addition, current issues on the taxation of carbon in each sector including construction will emphasise the stakeholders to prefer the concept of low carbon development as well as sustainable environmental insight. However, priority should also be placed on the selection of sustainable construction management techniques, use of heavy equipment, production of construction material, human activities at the site, and transportation (Hong et al., 2014). Furthermore, greater emphasis needs to be given to macro-level management, international collaboration, and the development of concepts, technologies, and standards related to low-carbon construction due to their significant contributions towards net-zero energy building development (Shi et al., 2015).

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The Rise of Expanded Polystyrene (EPS) Technology in Modern Construction A Focus on the National Housing Corporation (NHC) of Kenya

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Kenya continues to grapple with a significant housing shortage, with an estimated annual demand of approximately 200,000 housing units against a supply of only about 40,000 units. This substantial gap has led to the proliferation of informal settlements, increased urban congestion, and a growing population of citizens who cannot access decent shelter. In response to this crisis, the National Housing Corporation (NHC) has embraced modern construction solutions to accelerate delivery and reduce housing costs. One of the most promising innovations in this regard is the adoption of Expanded Polystyrene (EPS) technology.

EPS technology represents a paradigm shift in how houses are designed and built in Kenya. The technology involves the use of prefabricated panels made from polystyrene foam encased in a mesh of galvanized steel, which are then plastered with concrete for structural strength. These panels are lightweight, thermally efficient, easy to assemble, and cost-effective. Their adoption by the NHC aligns with national goals such as Vision 2030 and the Bottom-Up Economic Transformation Agenda (BETA), which both prioritize the provision of affordable and decent housing for all Kenyans.

1. What inspired the shift towards using Expanded Polystyrene (EPS) technology, and how does it support NHC's affordable housing strategy?

The motivation behind the NHC's adoption of EPS technology stems from the need for faster, more economical, and sustainable housing solutions. Traditional construction methods have often proved too slow and expensive to meet the current demands of urbanization and population growth. EPS, being a prefabricated technology, allows for faster construction, requires fewer skilled laborers, and offers considerable savings on building materials.

More importantly, the use of EPS supports the government's Affordable Housing Programme, which is one of the key pillars of the Big Four Agenda. EPS makes it possible to develop large-scale housing projects that are not only affordable but also environmentally sustainable. This technological approach resonates with the NHC's mission of providing decent and adequate housing through efficient and modern building solutions.

2. Could you share specific ways in which EPS has improved project delivery timelines and reduced overall building costs?

One of the most immediate advantages of EPS technology is the remarkable improvement in construction timelines. Since EPS panels are manufactured off-site and transported to the construction location ready for assembly, this significantly reduces on-site preparation and building time. Projects that would typically take 12 months using traditional methods can be completed in nearly half the time with EPS.
In terms of cost, EPS has shown the potential to reduce building expenses by up to 30%. For instance, a standard two-bedroom house built using EPS technology can cost around KSh 700,000 before finishing, which is nearly half the cost compared to traditional stone and timber structures. This cost reduction is achieved through savings on labor, foundation work, and material transportation, owing to the panels' lightweight nature.

Moreover, EPS panels require minimal support structures, reducing the need for extensive and expensive reinforcement. As a result, developers and government agencies are able to reallocate saved funds to improve the quality of finishes or expand the scope of housing projects.

3. What quality and safety measures are in place to ensure the long-term performance of EPS structures in Kenya's diverse environments?

Despite being relatively new in Kenya, EPS construction is not a compromise on quality or safety. The NHC has taken concrete steps to ensure that EPS-built structures are durable and safe across Kenya's diverse climatic zones. The panels used are composed of high-density polystyrene sandwiched between galvanized steel mesh, which provides mechanical strength and resistance to deformation.

Once installed, the panels are coated with concrete to enhance fire resistance, structural integrity, and overall durability. EPS buildings are also known for their excellent thermal insulation properties, making them suitable for both hot coastal climates and cooler highland areas. This thermal performance leads to long-term energy savings, especially in urban areas where air conditioning and heating costs are a concern.

Additional safety features include pest resistance, minimal water absorption, and resistance to mold and mildew. The NHC also ensures that clear guidelines are provided for installations, such as using hot torches to create channels for electrical and plumbing systems within the panels, preventing structural damage and ensuring clean internal finishes.

4. How is NHC working with engineers, contractors, and local artisans to encourage the uptake of EPS technology across the country?

A major factor in ensuring the success of EPS technology is the training and empowerment of professionals who use it. The NHC has launched comprehensive training initiatives together with partners such as NCA targeting engineers, contractors, artisans, and other construction workers. These programs are designed to build capacity and ensure that all stakeholders involved in housing delivery understand how to work with EPS efficiently.

To date, NHC has trained over 1000 contractors and artisans, and continues to expand its outreach, through seminars, workshops, site visit invitations as well as sensitization of students undertaking built environment courses in Universities, TVETs and Polytechnics. This initiative not only supports proper installation practices but also promotes the technology's uptake across public and private construction sectors. Furthermore, NHC has introduced a Partnership Policy that encourages collaboration with private developers, international investors, and technology providers to bring in funding and technical expertise.

Through such collaborations, NHC is fostering an ecosystem where modern construction methods like EPS are widely accepted and utilized, thereby accelerating housing development nationwide.

5. Can you share successful case studies or flagship housing projects where EPS panels have been used?

Several flagship projects have already demonstrated the real-world benefits of EPS technology. These projects serve as proof-of-concept and are helping to build public trust in the technology:

• NHC Changamwe Infill Project (Mombasa County): This initiative showcases the suitability of EPS in coastal conditions characterized by high humidity, intense heat, and corrosive salty air. EPS panels offer a corrosion-resistant solution that mitigates water absorption and significantly reduces maintenance costs. Additionally, the thermal efficiency of EPS helps occupants save up to 40% in energy bills by minimizing reliance on air conditioning.

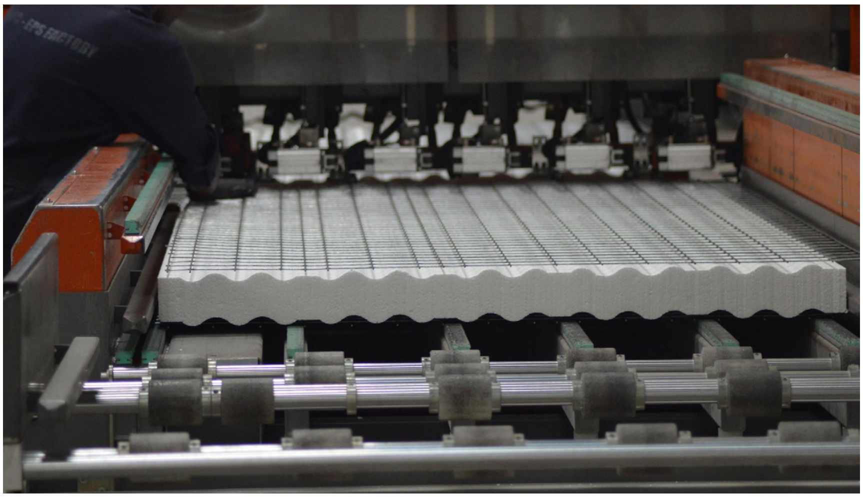
• La Casa Luxury Apartments (Rongai): A private development that used EPS panels supplied by NHC. The project reported a 25% cost saving, which was then used to enhance interior and exterior finishes, illustrating EPS's versatility in both low-cost and premium developments.

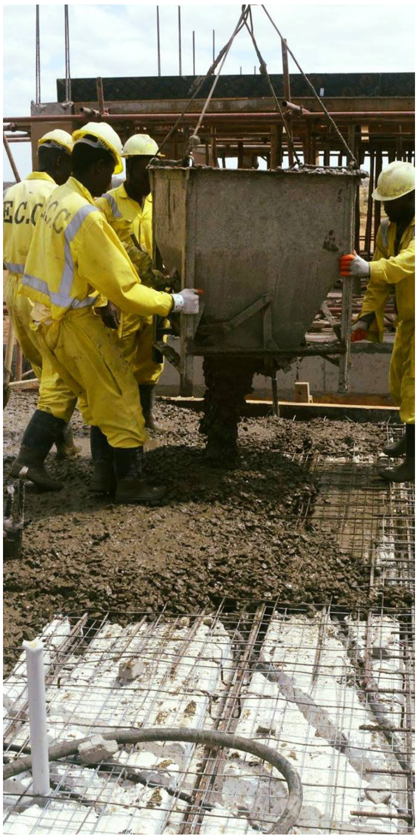
• Balozi Estate (Muthaiga North, Nairobi): Constructed in 2000, this early adoption project remains one of the best examples of the long-term durability and aesthetic appeal of EPS structures.

• Police Housing Units (Ruai): Here, EPS was used to construct residential units, a modern police station, and a canteen for law enforcement personnel. The success of this project demonstrated that EPS is not only suited for residential housing but also for institutional buildings.

In conclusion, the adoption of Expanded Polystyrene (EPS) technology by the National Housing Corporation represents a significant leap toward solving Kenya's housing challenges. EPS offers an innovative, efficient, and sustainable solution that reduces both construction costs and timelines while maintaining high standards of quality and safety.

By combining modern technology with strategic partnerships, capacity building, and real-world applications, NHC is demonstrating how Kenya can move from a housing crisis to a housing revolution. As awareness and training continue to expand, EPS is poised to become a cornerstone of Kenya's modern construction industry, bringing the dream of affordable housing within reach for millions of Kenyans.





The Future of Engineering Education in Kenya: Prospective benefits of Competency Based Curriculum system and Washington Accord

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Abstract

Kenya's education system is shifting towards a competency-based curriculum (CBC) learning. Competency-based learning (CBL) is an outcome-based, student-centered form of learning. Noting that, a 21st century trained engineer requires a global recognition, the Engineers Board of Kenya (EBK), is on course to onboard Washington Accord, a voluntary-to-join multilateral agreement body for the governance of engineering training and practice. Many articles have been published on the implementation of CBC in engineering within higher education institutions; however, the knowledge gathered so far lacks an integrative review literature analysis of the prospective benefits to accrue to engineers from its blend with Washington Accord's framework. The purpose of this review is to fill the gap. It summarizes the different approaches for implementing CBL, the effects of the pedagogy on student outcomes, tools to enhance its effectiveness, and assessment strategies. In addition, it has sampled the benefits of Washington Accord's membership for employability. Engineering education articles were obtained from several educational databases. The search was limited to articles published on the subject matter, and inclusion criteria consisted of peer-reviewed journal articles that address the use of CBC in engineering higher education and how membership of Washington Accord is beneficial. Articles were then classified, summarized, and evaluated. Theoretical and applied perspectives are provided illuminating the blend benefits to engineers.

Keywords: competency; literature review; pedagogy; Accord

1. Introduction

In the thought of today, education is regarded as a method of adjustment. Education is such an essential part of the fabric of life that we should expect it to be interwoven with that process of adaptation which characterizes every level of life at every moment of existence (Hendricks, 1926). It cannot only provide career and professional opportunities but more importantly, it also helps provide the understandings, insight, and problem-solving abilities upon which to draw for a lifetime (Hill, 2006). To George Counts, the author of the famous pamphlet,' Dare the School Build a New Social Order?' education is the means by which a society transmits and transforms its cultural heritage. As one of the leading "Frontier Thinkers", he called on the school to lead the way towards the creation of a more equitable society by inculcating a loyalty to a new social order. There are two approaches to the educational theory of any advanced country. The first one is through the writings of its great educators, and the other is through the forms which its educational institutions have assumed (Counts, 1930). In Kenya, the new Competency Based Curriculum (CBC) is a national heritage builder that is envisaged to propel upwards the power of learning among the citizenry. Its introduction coincides the onboarding to the Washington Accord by the Engineers Board of Kenya (EBK). The latter is a voluntary-to-join multilateral agreement body for the governance of engineering training and practice that is meant to open up the mobility of engineers across borders. The coincidental introduction of the two systems into the Kenya's knowledge economy heralds the impetus to investigate the combined prospective benefits.
Engineering education is nearly entirely scientific and technical yet the engineering challenges we face today are most of the time multidimensional and less technical in nature. The ongoing globalization of business and society has not helped, because engineering practice has also become a worldwide profession. Therefore, every engineer must have the capacity to understand societal cultures and circumstances. Originally, the engineering profession was inspired by the era of Leonardo da Vinci thinking, in which; craft, art and science shared a sacred harmony. However, in the last quarter of the 20th century, the global economy has since moved to the era of a multiplicity of machine-dominated specialties, marvelous capacities and insightful technocracy. This then means, engineering schools need to produce engineers who are less of technocrats but more of renaissance engineers. For a long time, engineering education in Kenya's universities has been using a passive approach to instructional learning in which students' success in examination is based on one's ability to reproduce notes

from memory. Since 2013, Kenya's education system has moved to Competency-Based Education (CBE); the acquisition and development of competences. By 2029, the first cohort of CBC graduates will be admitted to the university and those of them who will join engineering 'training' will be expected to undergo Competency-Based Training (CBT); the mastering of specific knowledge and skills whose aim is to spur up employability.

Most industries prefer engineering graduates to possess the current know-how to fix immediate problems; and also hold sufficiently deep theoretical background to resiliently adapt to future engineering challenges. Engineering as it were, is a professional learned art. This means, it is built on a formal system of study at the post-secondary education level. But what is a 'good' engineering education system? Which are the important topics to be taught, and how can they be fitted into the limited academic period of 5 years without overburdening learners? How are good students recruited? And where can the necessary faculty resources be found? While pondering over these questions, it ought to be noted that, "education for individual engineering disciplines cannot be considered in isolation from the wholesome of the "engineering" education problem or even more from the nation's "Education System". Accordingly, for Kenya, it has become a necessity to integrate education at all levels by bringing together technical, social skills, for example, communications courses, and scientific processes. In simple terms, the idea is to integrate; education, research and practice in the new knowledge economy, hence the CBC learning.

2. Previous related work

Traditional instruction, such as the typical lecture-based session, developed before textbooks were mass-produced, often involves delivering as much information as quickly as possible. The lecture method was one of the most effective and efficient ways to disseminate information and has often been used for this end. Because some faculty members may be poor lecturers, and because students are often poor participants in the lecture, this type of instruction has often allowed students to be passive in the classroom. Students, not knowing how to be active participants in the lecture, have relied on transcription, memorizing and repetition for learning. This method has heightened the unemployment problem among graduates in many countries, Kenya included. This is the reason, some scholars have asserted that, higher education ought to embed employability skills into the curriculum in order to equip graduates with the relevant

skills and attributes to secure employment. To be a big extent, a lot of importance is attached to studying a professional body accredited course like engineering to secure graduate employment (Souppez, 2023).In the US for example, 70.5% of engineering graduates (mechanical) normally wish to gain employment in the industry (Magarian and Seering, 2021).In Kenya, universities release about 500,000 per year into the job market and of this, only about 25% of youth are absorbed, leaving 75% to bear the burden of unemployment (Awuor,2013). This has made many young university graduates demoralized (Salah and Hussein, 2018). The problem has been attributed to; the lack of job experience, inadequate communication skills and the possession of qualifications that are not relevant to the job market (Kaliannan and Chandran, 2012).

The results have brought in some introspection. In fact, some scholars have emphasized on the need to reconfigure and re-invent the Kenyan university by transforming it from "Graduate-mill" to a development-oriented paradigm (Chege, 2015). This has made the higher education institutions today to respond to this growing concern for the adequacy of students' professional and career preparation by specifying the outcomes or abilities that are demanded in the market. Such outcomes are programmed to focus on assessing performance as well as knowledge, bridging the gap between university and career world. In Kenya for example, the Engineers Board of Kenya is not only looking into accrediting academic programs but is also pursuing ways to improve mobility of engineers across borders. The CBC program therefore is going to address the learning outcome for all programs which are to be offered in the higher institutions. This paper has the view that this approach is important and corresponds with the global education concept of Outcome-Based Education (OBE) rather than the traditional pedagogical teaching. This is to ensure each of the university programs is able to generate a holistic, successful student in the academic field and magnificent human capital. The new Competency-Based Curriculum has a great promise (Muller and Gamble, 2010).

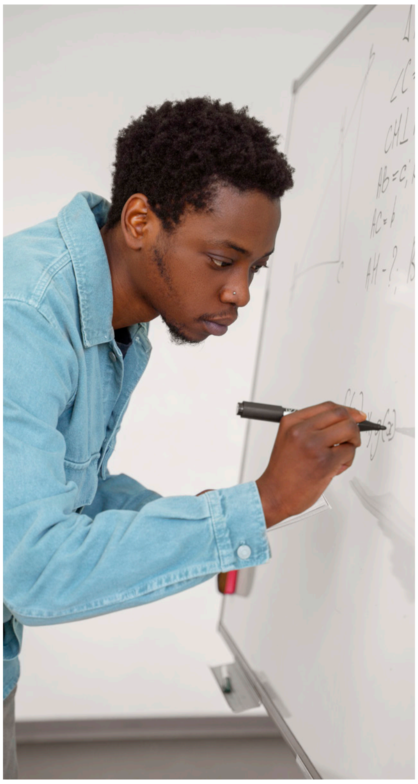
According to Scott, (2014), curriculum is defined a set of teaching and learning prescriptions for knowledge forming activity. A school curriculum therefore is simply a selection from a range of cognitions, skills, and dispositions available within a society. Scholars of old believe that the mentioned attributes are manifested in human practices of a discursive, institutional, hence involves intergenerational knowledge transfers. It follows then that choices also have to be made as to how a curriculum is constructed; that is, what relations are considered to be appropriate between the contents of the curriculum, its pedagogic forms, its learning strategies, and its evaluative criteria and apparatus. These choices of cognitions, skills and dispositions then, if they are to be considered reasonable, are to be placed within 'the logical space of reasons', meeting certain justification or rationale for them as curricular contents. This justification can take an epistemic form: a curriculum is in essence a framework for some type of learning or another; learning whether cognitive, skill-based or dispositional is understood as a knowledge-development activity; and therefore knowledge is central to the construction and realization of the curriculum. However, it then becomes necessary to determine what this knowledge is, and how it is formed and legitimated.

Learning, or so it can be argued, is an epistemic or knowledge-producing activity. An accepted, but not uncontested, view of learning is to theorize it as a process, with a range of characteristics. It has a set of pedagogic relations, in that it incorporates a relationship between a learner and a catalyst, such as a person, a text, an object in nature, a particular array of resources, an artefact, an allocation of a role or function to a person, or a sensory object. A change process is required, either internal to the learner or external to the community of which this learner is a member. In any learning episode, there are temporal and spatial arrangements, and these can be understood in two ways: first, that learning is internally structured, and second, that learning episodes are externally located in time and place. Learning is conditioned by arrangements of embodied, discursive, institutional or agential resources, and this has implications for the types of learning that can take place. Each learning episode has socio-historical roots. What is learnt in the first place is formed in society and outside the individual. It is shaped by the life that the person is leading. Learning then has an internalization element, where what is formally external to the learner is interiorized by the learner, and a performative element, where what is formally internal to the learner is exteriorized by the learner in the world. These elements of learning if and as they are realized constitute a knowledge-forming activity.

Competency Based Curriculum learning therefore as a form of Outcome-Based Education (OBE) is considered the brainchild of the sociologist William Spady. In his view, OBE is focused on organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences (Spady, 1977). This means starting with a clear picture of what is important for students to be able to do, then organizing curriculum, instruction, and assessment to make sure this learning ultimately happens. Outcomes are clear learning results that students need to demonstrate at the end of significant learning experiences. They are not values, beliefs, attitudes, or psychological states of mind. Instead, outcomes are what learners can actually do with what they know and have learned, in other words, they are the tangible application of that which has been learned. In real sense therefore, outcomes are actions and performances that embody and reflect a learner's competency in using content, information, ideas, and tools successfully. Having learners do important things with what they know is a major step beyond knowing itself to demonstrate competence.

In literature, the concept of competence has been defined as a knowledge, skill, ability, personal quality, experience, or other characteristic that is applicable to learning and success in school or in work. In the OBE paradigm, the instructional and assessment/evaluation practices are explicitly designed for ensuring the attainment of predefined learning outcomes that are aligned to broader, long-term educational objectives. It is now the underlying paradigm followed by global accreditation efforts such as the Washington Accord (ratified in 1989), which is an agreement to accept undergraduate engineering degrees that were obtained using outcome-based education (OBE) and outcome-based accreditation (OBA) methods. The scale of the shift to OBE can be gauged from the fact that some educational experts are now calling it as one of the top five major changes in engineering education in the last century. The main focus then is planning how to meet the changing needs of students and society. In aligning to this expectation, the higher education institutions usually adjust their curriculum to meet new needs. Further, surveys suggest that students consider the programs and majors that colleges provide to be the most important factor in deciding where to enroll. As a result, in order to compete successfully for students, every college must create courses and programs that reflect their interests and concerns.

Competency-based education can be defined as providing education through which individuals can gain the necessary knowledge, attitude, and skills so that they can acquire competence. "Outcome-based" means deciding the



results that the education community wants ahead of time — before teaching — and then taking the necessary steps during instruction to achieve them. Therefore, out¬ come-based education philosophy recognizes the need to involve the entire education community in determining what students need to learn and then in doing whatever is necessary and reasonable to be certain that each child does learn. In standards-based education, [individuals] are expected to reach the pre-set standards. While the standards of the program are being set, acquiring certain competencies comes before gaining competence… In skills-based education, the aim is to enable individuals to acquire the skills necessary to perform a job or task. Skills-based education is one of the sub-dimensions of competency-based education... When it comes to qualifications-based education, it can be said that it is to sometimes includes skills-based education, standards-based education, or competency-based education because it is about identifying whether learning takes place according to certain standards set beforehand to obtain a qualification. However, the concept of qualifications-based education is a suitable concept for higher-level education received to continue specializing in a subject. From the foregoing, it is clear that, CBC is a form of OBE.What is critical then is the outcome targeted, whether it is skills, standards or competency, the planning needs to be clear on the final outcome (Tanner, 1966). . This paper aims to document the likely benefits of CBC learning for engineers under Washington Accord governance. It has six parts from; introduction, previous related work, method, results, discussion and conclusion.

3. Methodology

3.1 Overview

This paper has deployed the integrative literature approach to review, critique, and synthesize representative literature on the contribution to the society of the two genres; objective based education and the Washington Accord engineering governance and practice framework (Bem, 1995). The review did not to cover all articles ever published on the topic but rather has combined perspectives to create new theoretical models. The aim was to assess, critique, and synthesize the literature on the workings in a way that has enabled elucidation of a new theoretical framework and perspective. Knowing that CBC is a new, emerging topic in Kenya, the purpose rather was to create an initial or preliminary conceptualizations and theoretical models. A creative collection of data was used not to cover all articles ever published on the topic but was to combine perspectives and insights from different fields or research traditions. The first step was to find

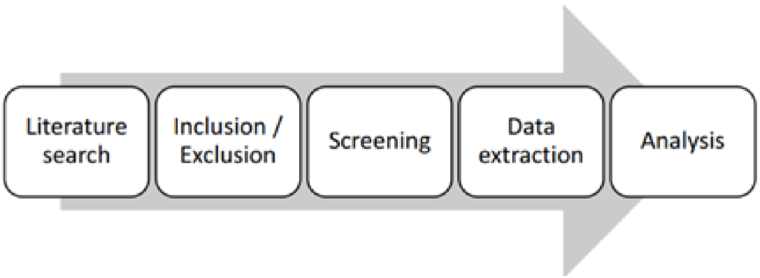


Figure 1: Sequential flow of literature search

the evidence, while noting that objective-based education has a long history which made the task of finding everything needed became formidable endevour.

The search began by setting limits of inclusion, screening and extraction before analysis as illustrated in Figure 1.

The strategy for selecting the literature was to identify a relevant article on objective based education, and benefits of joining Washington Accord. Hence keywords and databases used were narrowed down to the same two themes independently. The study ensured that the recently published literature and older literature were both systematically searched. The older literature was examined by reviewing the citations from the articles obtained through the search of selected databases. Recently published literature was examined by using the Web of Science.

3.2 Writing

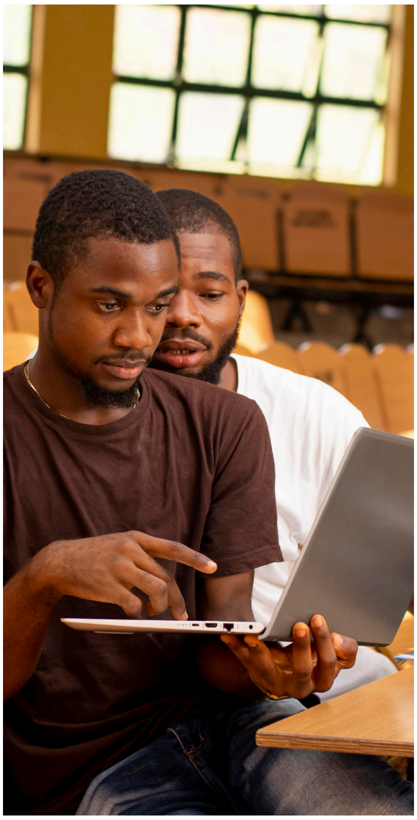
In writing the review the research used "tell a story" Mode by critically analyzing the literature and arriving at specific conclusions about it. This was followed by the critical analysis of literature which involved the careful examination of the main ideas and relationships of the issue of potential integrative contributing benefits of the two genres to the Kenyan society and providing a critique of existing literature. In critiquing, the study did a critical evaluation of how well the literature represents the issue. It is here the study first deconstructed the genres into their basic elements. These included the history and origins of the genres, their main concepts, and so on. Careful analysis was used to expose knowledge that may be taken for granted or hidden by years of intervening research. The analysis allowed the study to reconstruct, conceptually, the genres for a clearer understanding of them and to assess how well they are represented in the literature. This laid the foundation for critique, the product of critical analysis. Critique identified the strengths and key contributions of the literature as well as any deficiencies, omissions, inaccuracies, and other problematic aspects of the literature. The critique identified aspects of the phenomenon that are missing, incomplete, or poorly represented in the literature, as well as inconsistencies among published perspectives on how the two genres work in concert for the benefit of the society (Torraco, 2005).

3.3 Synthesizing new knowledge

With the strengths and deficiencies of a body of literature exposed, the study took advantage of the breadth and depth of the insights extracted to create a better understanding of the two genres through synthesis. The synthesis integrated existing ideas with new ideas to create a new formulation of new common look; the contribution of CBC education and Washington Accord for engineers. Synthesizing the literature meant that the review weaved the streams of research together to focus on core issues rather than merely reporting previous literature. Synthesis was not taken as a data dump but as a creative activity that produced a new model. The result of a comprehensive synthesis of literature was that new knowledge or perspective was created despite the fact that the review summarized previous research.

4. Results

A total of fifty articles were identified, all which carried relevant information on either CBC learning and the benefits of accreditation of engineering practice by Washington Accord. In summary, it was realized that, a number of countries such as; Pakistan, United Kingdom, United Arab Emirates, United States of America, Saudi Arabia, Singapore, Qatar, China, and Malaysia have on boarded the Objective Based Education. From the sentiments on the system gathered from beneficiaries of CBC system from these countries, the method has acquired a global international recognition for accreditation standards, practices, and attitudes for all professional disciplines. Suffice therefore to



say that OBE paradigm is now the underlying paradigm followed by global accreditation efforts such as the Washington Accord (ratified in 1989). The shift to OBE is so pronounced that some education experts identify the shift to OBE and accreditation as one of the top 5 major changes of the last 100 years (Ho et al, 2023). On the whole, OBE has helped in improving the educational standards and outcomes by ensuring proper planning of curriculum and assessment and their alignment with the program objectives and desired outcomes. OBE is also flexible in the sense that it does not dictate the choice of specific education strategies or teaching methods—it only says what should be the outcome. New OBE schemes have also diversified in response to early misgivings about OBE (related to excessive paperwork, and bean-counting-like auditing) and now admit diverse types of evidence (including qualitative and quantitative, formative and summative, formal and informal assessments).For Kenya therefore, these assurances are a helpful starting guide for faculty members new to OBE, while also offering a broader perspective to experienced faculty members and administrators particularly for engineering education.

5. Discussion

The Washington Accord known as a mutual recognition agreement between national engineering regulatory bodies was signed in 1989 by six founding signatories. Through this mutual recognition agreement, the signatories recognize that the formal educational programs accredited by the respective signatories are substantially equivalent. The stated objective of the Washington Accord is to ease the path of engineering graduates to professional registration or licensing in different jurisdictions. Since 1989, the signatories to the Washington Accord has increased threefold with an additional many other countries as currently provisional signatories. This rapid expansion is a reflection of the need for international recognition of educational qualifications and competency across borders in an increasingly globalized world. Engineering accreditation bodies, particularly in developing countries, are proactively seeking recognition and mobility of their graduates, like the case of Kenya.

The Washington Accord is one of seven mutual recognition agreements managed by the International Engineering Alliance. Signatories to the Washington Accord recognize the substantial equivalency of programs accredited by the signatory bodies (Anwar and Richards, 2015). Signatories to the Washington Accord agree to make every reasonable effort that licensing bodies in respective countries recognize this substantial equivalency. The Washington Accord also referred to as an international mutual recognition agreement (MRA) has, as of Jan. 2024, had 25 signatory bodies with full rights and 6 signatory bodies with provisional status.

25 SIGNATORIES WITH FULL RIGHTS **OF PARTICIPATION IN THE** ACCORD

Qualifications accredited or recognized by other signatories are recognized by each signatory as being substantially equivalent to accredited or recognized qualifications within its own jurisdiction. Substantial equivalency applies only to programmes accredited by the signatories within their own jurisdiction.

- **Korea** - Represented by Accreditation Board for Engineering Education of Korea (ABEEK) (2007)
- **Russia** - Represented by Association for Engineering Education of Russia (AEER) (2012)
- **Malaysia** - Represented by Board of Engineers Malaysia (BEM) (2009)
- **China** - Represented by China Association for Science and Technology (CAST) (2016)
- **South Africa** - Represented by Engineering Council South Africa (ECSA) (1999)
- **New Zealand** - Represented by Engineering New Zealand (EngNZ) (1989)
- **Australia** - Represented by Engineers Australia (EA) (1989)
- **Canada** - Represented by Engineers Canada (EC) (1989)
- **Ireland** - Represented by Engineers Ireland (EI) (1989)
- **Hong Kong China** - Represented by The Hong Kong Institution of Engineers (HKIE) (1995)
- **Chinese Taipei** - Represented by Institute of Engineering Education Taiwan (IEET) (2007)
- **Singapore** - Represented by Institution of Engineers Singapore (IES) (2006)
- **Sri Lanka** - Represented by Institution of Engineers Sri Lanka (IESL) (2014)
- **Japan** - Represented by JABEE (2005)
- **India** - Represented by National Board of Accreditation (NBA) (2014)
- **United States** - Represented by Accreditation Board for Engineering and Technology (ABET) (1989)
- **Turkey** - Represented by Association for Evaluation and Accreditation of Engineering Programs (MÜDEK) (2011)
- **United Kingdom** - Represented by Engineering Council United Kingdom (ECUK) (1989)
- **Bangladesh** - Represented by The Institution of Engineers Bangladesh (IEB) (2023)Provisional Status Approved in 2016. Full Signatory Status recognition from 2023
- **Costa Rica** - Represented by Colegio Federado de Ingenieros y de Arquitectos de Costa Rica (CFIA) (2020)
- **Mexico** - Represented by HYPERLINK "http://cacei.org.mx/" \t "_blank" Consejo de Acreditación de la Enseñanza de la Ingeniería (CACEI) (2022)
- **Pakistan** - Represented by Pakistan Engineering Council (PEC) (2017)
- **Peru** - Represented by HYPERLINK "http://icacit.org.pe/web/eng/" \t "_blank" Instituto de Calidad y Acreditacion de Programas de Computacion, Ingenieria y Tecnologia (ICACIT) (2018)
- **Philippines** - Represented by Philippine Technological Council (PTC) (2023)Recognition date as full signatory status applies from 2023 to Tier 1 programmes as defined by the tier classification system used in the Philippines.
- **Indonesia** - Represented by Indonesian Accreditation Board for Engineering Education (IABEE) (2022)

6 PROVISIONAL SIGNATORIES THAT ARE RECOGNISED **AS HAVING** APPROPRIATE SYSTEMS **AND PROCESSES IN PLACE TO DEVELOP TOWARDS BECOMING A** FULL SIGNATORY

- **Chile** - Represented by Agencia Acreditadora Colegio De Ingenieros De Chile S A (ACREDITA CI)Provisional Status Approved in 2018.
- **Thailand** - Represented by Council of Engineers Thailand (COET)Provisional Status Approved in 2019.
- **Myanmar** - Represented by Myanmar Engineering Council (MEngC)Provisional Status Approved in 2019.
- **Saudi Arabia** - Represented by Education and Training Evaluation Commission (ETEC)Provisional Status Approved in 2022
- **Nigeria** - Represented by Council for the Regulation of Engineering in Nigeria (COREN)Provisional Status Approved in 2023
- **Mauritius** - Represented by Institution of Engineers Mauritius (IEM)

Table 1: 25 Signatories of Washington Accord and six with provisional status (Source: https://www.internationalengineeringalliance.org/accords/washington/signatories)

The United States of America's Accreditation Board for Engineering and Technology (ABET) and the Engineering Council (EC) UK are amongst the six founding signatory bodies of the Washington Accord. One of the main objectives of WA read…. "Through the Washington Accord, ……… the signatories recognize the substantial equivalence of such programs in satisfying the academic requirements for the practice of engineering at the professional level. This is further qualified by jurisdiction in that "The Washington Accord only recognizes engineering programs accredited within the signatories' own jurisdictions". ABET define jurisdiction for the purposes of the Washington Accord as the U.S. (presumably all U.S. territories) whereas EC states that their jurisdiction for the purposes of the Washington Accord "… applies to programs accredited at universities in England, Scotland, Wales and Northern Ireland only". Therefore, British Overseas Territories and Crown Dependencies such as; Gibraltar, Jersey, Guernsey, Isle of Man etc. are excluded. The Washington Accord is also significant in the International Professional Engineers Agreement (IPEA). This agreement supersedes the Engineers Mobility Forum of 1997. The EC is listed as a member of the IPEA and also the United States Council for International Engineering Practice - but not ABET. The IPEA states that "…. if the organization accrediting engineering degrees in a jurisdiction holds signatory status of the Washington Accord, the above-mentioned requirement for the academic achievement will be deemed to have been

met in full".

To achieve the goal of developing new engineering disciplines and cultivating students with high moral standards and innovative skills, an improved educating mode based on CBC learning will align with the Washington Accord's expectations. The requirements of the Washington Accord on engineering certification, expect that the teaching objectives for innovative engineers under the new engineering training must be re-set. Preferably, a five-year blended teaching that includes; group-based and layered teaching approach need to be adopted to promote the progress of all students. Using a five-element process indicator need to be proposed to evaluate the effectiveness of engineering training in Kenya. This is likely to promote students' capacity development in knowledge and skills with enhanced productivity practice.

Anchored by the goal of building a strong education and talent into the future, a lot has been discussed. Mainly, it is clear that today, education must be based on the use of the communication and digital technology. The international trend on this is that, teaching modes and the rationalization of teaching evaluation must be aligned to OBE. Scholars today talk of blended learning modes aimed at the programming introductory courses, and their flexibility which ostensibly can help students achieve better results. Other educators insist on improving practical quality evaluation schemes for university teaching by improving the prediction accuracy. To a big extent in the digital learning, it has been established that, human-machine collaboration, targeting individual development, can help improve students' aptitude. Based on the necessity analysis of personalized teaching in the new engineering education for Kenya, this paper proposes an improved educating mode in all engineering disciplines so that it aligns with Washington Accord's requirements.

Developing teaching objectives based on the Washington Accord as a formal member of the international undergraduate engineering degree's mutual recognition agreement will require Kenya to formulate her engineering education accreditation requirements standard to be in tune with outcome-based education (OBE) concept. The latest version of Washington Accord has added new engineering certification requirements, which requires innovative engineers to integrate sustainable development values and goals into their work ethics. Accordingly, engineering education in Kenya will have to focus on a wider range of interdisciplinary complex engineering issues that can blend with other disciplinary knowledge and technology to solve emerging societal problems. The main idea of promoting the changes of engineering education methods is to transform teacher-centered methods to student-centered and use problem-based learning methods. Through the systematic analysis of the engineering certification standards of the Washington Accord, Kenya's engineering faculties are called not only to reform and innovate engineering education, but also to align to the "trinity" teaching objectives of knowledge, skills, and attitudes (KSA) for comprehensive training of future engineers in the new engineering field of the 21st century.

The "trinity" teaching objectives will be enhanced by grouping students according to the OBE-oriented teaching, a hierarchical project-based teaching approach designed to meet individual student's needs, from the basic, through the challenging, up to including the advanced complex problem levels. In this, every student is expected to complete pre-class preview, group discussion, independent design, hands-on practice in class, and post-class result analysis for basic-level tasks. Throughout the program, the students will be encouraged to challenge themselves by combining engineering simulation programming with other courses so that they build skills in solving complex system's problems replicating real-life situations. Students will also be taught to optimize control systems to solve the problem of insufficient application of knowledge and achieve the advanced goal of using innovative thinking to further develop skills in solving even more complicated problems. By integrating theory and practice throughout the entire process of participation, the students will be caused to learn actively with a clear goal which will enhance their knowledge and skills based on engineering at all levels.

6. Conclusion

From the analysis, it is established that there exist more than 400 accredited programs in many countries that are aligned to Washington Accord's requirements for engineering education (Smith et al., 2024). While the US, the UK, and Australia have dominance over other countries in their continents, a balanced distribution among countries is seen in Asia. There has been a fall-off in the number of accredited programs globally (except the US) due to multiple factors. Regarding discipline attribution, it is relatively different among continents, with management in conjunction mostly with industrial engineering in Asia and America, civil engineering in Australasia, and others in Europe. As of January, 2024, there were 25 full signatories of Washington Accord and six Provisional Signatories. In Africa only South Africa is a full member while Nigeria is in the provisional list. Kenya is still being evaluated to join this Mutual Recognition Agreement that is, the Washington Accord.

The transformation of engineering undergraduate programs towards global practice of outcomes-based accreditation (OBA) will entail a huge challenge to universities in Kenya as there is mounting pressure for infusion of desirable and yet measurable graduate competencies into its offered programs in order to fulfil professional bodies accreditation criteria. Hence, in view of providing a sense of direction to the local engineering education community, Washington Accord (WA) ensures that accredited programs synonymously mean that its graduates are equipped with professional abilities obtained through an innovative outcomes-based engineering programme. However, further complication is likely to unfold as industries are continuously evolving to meet rapid global demand and practice; hence defining set of competencies that can accurately map attributes outlined by industry with the aim of addressing 'skill-gap' will continue to be a challenging endeavor for higher education sector. The effectiveness of the OBE criteria outlined by WA in terms of attainment of graduate attributes which would enable graduates to take on challenging careers in the industry is critical for Kenya. This is best realized when the the relationship between the outcome-based accredited criteria and the attainment of graduate attributes outlined by WA is well configured in curriculum planning.

This is going to be a major challenge for engineering education, more particularly, the bringing of the largely separate worlds of engineering education and engineering practice closer together. There are however compelling reasons why the two worlds need to enter into productive dialogue. It is increasingly felt that the gap between what engineering education offers and what the world of engineering practice needs has widened. In her report on the state of engineering education globally, Graham points to the tension between "what engineering science professors want to teach engineers to do, so that they can become young scientists and PhD students, and the needs of government and society, which is to create engineers to contribute to economic development and growth". Instructively, it is clear that graduates of professional programs need to be well-prepared for their future careers and for their future contributions to societal and technical development. This means that engineering education is going to play a big role in closing the gap between education and practice by adapting to OBE pedagogy. Engineering education in this pursuit will have to respond to the integration of the Sustainable Development Goals (SDGs), emerging technologies, employability and lifelong learning. The future of engineering education and how problem and project-based learning could be part of the answers. The higher education institutions educating engineers for 2030 need a curriculum, learning goals and qualification profile that are aligned to WA's requirements to reduce challenges facing engineers.

Well, the challenges are lining up, however, engineering education in future will therefore require a student-centered and flexible curriculum, personalized learning environments and transformation of learning experiences into students' competences. That is why this paper is suggesting problem-based and project-organized learning (PBL) for the future curriculum for engineering education in Kenya. The approach embraces elements such as problem orientation, communication, teamwork, interdisciplinary, participant-directed learning, crit-

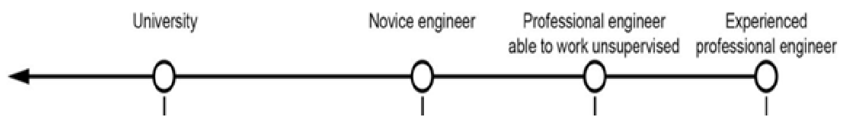


Figure 2: The path towards becoming an experienced professional engineer

ical thinking and creativity. PBL is focused on students' learning, providing experiences and ownership over the learning process by analyzing and solving real and authentic problems. The confidence on PBL pedagogy is strong because the method encompasses a contextual understanding of engineering knowledge and the design processes needed to equip the students with the skills into the future. Furthermore, this combination of contextual problems and engineering knowledge forms a platform for integrating the SDGs into education which again also opens up a landscape of possibilities in developing and applying the engineering competencies needed for future professional practice (Kolmos et al., 2020).

The contextual problems and engineering knowledge skill is built around such concepts like; Socially Responsible Design (SRD), Appropriate Technology (AT) and Human-centered Design (HCD) that end up being integrated into a pedagogical model (Locale). These attributes do focus student effort on the socio-cultural, technical, economic and environmental aspects of life (Bissett-Johnson et al.,2019). In fact, historically PBL is praised for producing strong educational results in engineering. It is actually a practice-based education (PBE) as a centered on solving complexities. The PBL framework entails three main elements: (1) the context of authentic engineering practice, (2) supporting learners' agency in the process of becoming professionals, and (3) opportunities to work and learn simultaneously (Mitchell et al, 2019).

This framework can easily reform the traditional engineering school towards student-cent red pedagogy. It integrates existing discipline-specific content with threads of professional skills and design through a backbone of problem-based learning experiences (Mann et al, 2020). One of the main goals of this student-centered pedagogy is to balance the need for an innovative education, which meets the demands of graduates and their employers, with the constraints and momentum of their existing curriculum. This enhances the students' preparedness for the labour market. Its main curriculum components include; knowledge and problem modes, variation in problem and project approaches, an inter-linked full-scale curriculum and focus on PBL competences and employability skills. The graduates from the system will have a higher level of preparedness in terms of generic and contextual competencies. The domain-specific competencies related to natural sciences will be watered down but the engineers will become problem-solvers instead as was done for physicians' training sometimes back (Cooke et al, 2010). In this way, this paper believes that, engineering education will respond positively to societal challenges. The planners must quickly think on how to develop a new conceptual framework for engineering curricula that will align to WA's requirements. This will bridge the gap from university through novice engineer, professional engineer up to experienced professional engineer, see Figure 2 above.

The future of engineering education in Kenya will require a holistic integration of a structured approaches for the systematic (re-)alignment of professional education initiatives. Engineering education is obviously a critical investment for the further development of industry and society. However, future engineers will need more than just a strong technological background, but rather a competence-based engineering education. This is the reason as to why engineering is featured prominently in the Next Generation Science Standards (NGSS). The disciplinary core ideas of engineering (as described in the NGSS) can be disregarded safely if the practices of engineering are better articulated and modeled through student engagement in engineering projects, and this is the way to make Kenyan engineers benefit in future.

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Securing Kenya's Infrastructure: An EBK Initiative for Stronger Engineering Standards and Safer Communities

1. Introduction: Building the Nation

Engineering and aconstruction are pillars of Kenya's economic growth and transformation. These sectors create jobs, attract investment, and provide the infrastructure essential for quality living and business operations. From roads, bridges, and buildings to clean water supply, energy distribution, and telecommunication networks, engineering services are central to nearly every aspect of national development.

Kenya's Vision 2030 and subsequent development blueprints place infrastructure and industrialization at the heart of economic and social progress.

As demand for infrastructure continues to grow, so does the need for strong regulatory systems that ensure quality, safety, environmental protection, and value for investment in the built environment.

2. Legal, Regulatory and Institutional Framework for the Built Environment

Kenya's construction industry operates under a comprehensive legal and institutional framework that governs the entire lifecycle of infrastructure projects—from planning, design and construction, to operations, maintenance, and eventual decommissioning.

At the heart of engineering regulation is the Engineers Board of Kenya (EBK), which is mandated to register and license engineers and engineering consulting firms (ECFs), regulate professional engineering services, set standards, and promote continuous professional development. EBK's regulatory role covers all aspects of engineering practice, ensuring that infrastructure projects meet technical, safety, and ethical standards.

The Board of Registration of Architects and Quantity Surveyors (BORAQS) oversees the architectural profession, including the registration and regulation of architects and quantity surveyors involved in design, cost planning, and management of building projects.

The National Construction Authority (NCA) regulates the construction sector, registering contractors, accrediting construction workers and site supervisors, and ensuring quality control at construction sites.

Other key regulators include:

• National Environment Management Authority (NEMA): Oversees Environmental and Social Impact Assessments (ESIAs) and environmental compliance for infrastructure projects.
• Kenya Bureau of Standards (KEBS): Sets and monitors standards for construction materials and practices.
• Energy and Petroleum Regulatory Authority (EPRA): Regulates energy infrastructure and installations.
• County Governments: Approve building plans, conduct site inspections, and oversee local development control.

Together, these institutions form a multi-layered but complementary system that supports safety, quality, sustainability, and orderly development. However, maximizing their effectiveness depends on coordination, data-sharing, and a whole-of-government approach.

3. Problem Statement: Building Safety in Focus

Kenya has made major strides in strengthening its built environment. Most infrastructure projects and buildings today are developed in accordance with established regulations, supported by a solid pool of trained engineers, architects, and qualified contractors.

However, challenges remain with a few failures in infrastructure and systems recorded, especially in the buildings sub-sector. The root causes often include:

• Private developers bypassing professional processes to cut costs.
• Inadequate technical capacity in some counties to review, approve and inspect developments, .
• Weak enforcement of standards in certain areas.

As a result, a few non-compliant structures have collapsed, tarnishing the reputation of an otherwise competent and progressive industry.

4. EBK's Strategic Interventions

To prevent further incidents and elevate engineering standards, EBK has implemented several strategic reforms and initiatives:

a) Inter-Agency Collaboration
Recognizing the need for joint enforcement and oversight:

• The Board is actively involved in the Multi-Sectoral Agency Consultative Committee (MSACC) to coordinate compliance initiatives across regulators.
• The Board is pushing for integration of digital portals across agencies to support real-time data-sharing, streamline inspections, and enable unified decision-making.

b) Engineers Projects Registration Portal

To enhance accountability:

• EBK is in the process of strengthening its Engineers Project Registration Portal, enabling better tracking of engineer's involvement in projects, and providing safeguards against forgeries of engineering documents submitted at the counties for development approvals.

c) Engineering Capacity Development

To increase the availability and competence of engineering professionals:

• EBK was central in the development of the Public Service Commission (PSC) approved Career Progression Guidelines for engineers, technicians, and artisans, ensuring structured growth from graduate to professional level.
• The Board plans to conduct a Human Resource Inventory of engineers in all counties to identify gaps and guide deployment.
• Professional Engineer (PE) registration processes are in the tail end of digitization.

d) Other Strategic Measures

• EBK is finalizing Regulations for Engineering Works and Services, to provide clearer compliance guidelines.
• It is actively involved in drafting the Public Works Policy and the Building Standards and Control Bill through the MSACC.
• The Board is also actively contributing to the sensitization of the National Building Code amongst members.

5. Conclusion: Engineering Excellence, Public Safety

Kenya's built environment is rapidly evolving—and with the right frameworks, skilled professionals, and stronger collaboration, it can be a symbol of resilience, innovation, and national pride. EBK remains committed to raising engineering standards, promoting professionalism, and ensuring that every project upholds the highest levels of safety, efficiency, and sustainability.

Through these efforts, the Board envisions a future where every building and infrastructure development reflects the strength of Kenya's engineering sector—and where public confidence in the safety of the spaces we live and work in continues to grow.


HYUNDAI
DOOSAN

The Evolution of Materials Science and Its Role in Advancing Solar Energy Technologies

By EiK correspondence

Materials science is an interdisciplinary space that explores the world of engineering in as far as it interacts with principles of physics and chemistry to come up with novel solutions for various problems in society. It forms a conduit between the general field of engineering and natural sciences by making the study of materials the focal point of its essence.

Being an interdisciplinary space, materials science finds itself taking a forefront role in advancing different revolutionary technologies within the engineering space, one of them being solar energy technologies.

Material science itself has evolved significantly from a once minimally explored field to a now multifarious space that spearheads all kinds of technologies in varied fields. History recognizes three phases of civilization as the Stone Age, Bronze Age, and the Iron Age, according to the materials man was predominantly using to make his everyday items.

Materials through the Ages

During the Stone Age, human beings used such natural materials as stone and bone to make tools. The Bronze Age saw bronze being the material of preference while during the Iron Age, iron, and steel were the dominant materials of choice. As man evolved, so did his knowledge and interest in materials. This then paved way to early metallurgy, which explored smelting methods for various metals such as copper and iron.

The Cold War

The Cold War marked a defining era in the evolution of materials science. During this period, the use of materials evolved from basic everyday use to the development of nuclear weapons. The need for materials in development of nuclear weapons necessitated deeper studies into the nature of materials, which knowledge would later be instrumental in developing weapons, aircraft, and submarines for the war.
Over the years, materials science morphed into a distinct discipline that combines various aspects of the sciences and engineering to catalyze advancements in technology and sustainability. Areas such as energy, healthcare, and built environment have materials science to thank a great deal for their advancement in recent decades.

Energy particularly has evolved significantly as a field, with renewable sources being a focal point. Solar energy arguably takes the cake in the realm of renewable sources of energy, owing mostly to the fact that it is highly abundant and relatively easy to harness. Through such technologies as thermal systems and photovoltaic cells, solar energy provides a clean and fairly cost-effective alternative to non-renewable sources of energy.

Solar energy technologies

Solar energy technologies date all the way back to the beginning of the 19th century. However, modern photovoltaics gained traction somewhere halfway through the century when the silicon solar cell was invented. The invention of the silicon solar cell was groundbreaking because it could be melded with different elements to develop semiconductors which had the ability to convert more sunlight into electricity than earlier versions of solar cells. With knowledge from materials science, researchers kept getting better at developing this type of solar cell because then they could figure out how to work atomic structures to improve its conductivity.

The researchers soon progressed to the thin-film solar cells as an alternative to the silicon solar cells. At this stage of development, they were able to make solar panels that were more lightweight using materials like copper indium gallium selenide. Unfortunately, they had to trade off the higher efficiency of earlier solar cell versions for the flexibility of the thin-film solar cells.

After the thin-film solar cells came perovskite materials a little over a decade into the 21st century. These compounds have unique crystal features with an impressive ability to absorb light. They are also more efficient and do not cost much to manufacture. However, they are not very stable in the long term, a shortfall researchers are currently working to address.

As solar technology keeps gaining popularity, researchers are under more pressure than ever to develop solar energy products that are sustainable and friendly to the environment, such as biodegradable polymers and energy-efficient semiconductors. The emergence of new materials and manufacturing processes emphasizes the fact that the role of materials science in advancing solar energy technologies remains pivotal currently and in the foreseeable future.

IEK Membership Report

The IEK membership committee meets every month to consider applications for membership of the various classes received at the secretariat. The IEK council at its, 534th and 535th council accepted the following members under various membership categories as shown below;

MEMBERSHIP CLASS	NUMBER ACCEPTED-534th COUNCIL	NUMBER ACCEPTED-535th COUNCIL	TOTAL
FELLOW		2	2
CORPORATE	11	2	13
GRADUATE	139	158	297
GRADUATE ENGINEERING TECHNOLOGIST	6	40	46
GRADUATE ENGINEERING TECHNICIAN	5	12	17
STUDENT	27	57	84
TOTAL	**188**	**271**	**459**

During the period, we had 2 members who transferred from the class Corporate to Fellow member 13 from Graduate to Corporate member. In addition, we had 297 graduates, 46 graduate engineering technologists, 17 graduate engineering technicians and 84 students were accepted as members.

Gender Data

Class	Male	Female	Percentage (Male)	Percentage (Female)
Fellow	2	0	100%	0%
Corporate	13		100%	0%
Graduate	241	56	81%	19%
Graduate Engineering Technologist	38	8	83%	17%
Graduate Engineering Technician	16	1	94%	6%
Student	54	30	64%	36%
TOTAL	**364**	**95**	**79%**	**21%**

Summary

Gender	No.	Percentage
Male	364	79%
Female	95	21%
	459	100%

534TH APPROVAL

CORPORATE

SNO	NAME	MEMBER NO.
1.	Abdirashid Hajj Mohamud	M.12211
2.	Abdirahaman Bashir Somo	M.5038
3.	Edwin Obegi Moruri	M.9910
4.	George Otieno Andiego	M.12565
5.	Ibrahim Adow Hassan	M.7846
6.	Josphat Lenaiyarra Lenaiyarra	M.9934
7.	Robert Nyongesa Kasamu	M.13036
8.	Sammy Nganda Ngumbi	M.11914
9.	Samuel Kibe Mburu	M.7890
10.	Sharon Jepchirchir Kimatui	M.8846
11.	Titus Cheptumo Cherutich	M.8498

533RD APPROVAL

FELLOW

S/N	NAME	MEMBER NO.
1.	Gerald Mukuha Wagana	F.339
2.	Samson Mwanzia Kitwili	F.2929

CORPORATE

S/N	NAME	MEMBER NO.
1.	Hesbon Odhiambo Bengo Opuko	M.9844
2.	John Kipkorir Tonui	M.7956

The council invites Engineers and affiliate firms to apply for membership in the various membership classes, kindly follow the link members.iekenya.org to register or scan the QR Code below to apply for membership;

Student Voices

Kiprop Elijah, 21
Kenyatta University,
Bsc. Aerospace Engineering
Year Of Study: 3rd Year

Materials have defined human survival since pre-medieval times, when our ancestors' crafted tools from stone. Today, materials engineering is more critical than ever, with the increasing concern for sustainable use of our world's finite resources. Materials Engineering drives modern advancements by developing materials for products and structures that meet human needs.

Material Science, a fundamental unit taught in our first year of Aerospace Engineering, reveals the essence of engineering. Everything we design, imagine or build must take form, and that form depends on the material. Rockets get to space and back and planes soar the skies, because of our mastery of material properties. Feats that just over a century ago, were an absolute impossibility. Our lecturers have taught deeper principles that govern how materials behave, and to see materials as solutions waiting to be discovered, underpinning their role almost every engineering breakthrough.

One audacious development is the success of NASA's Parker Solar Probe, proving how advanced materials can make the seemingly impossible happenings, like "touching" the Sun, a reality. Kenya's growing aerospace sector offers opportunities for low-cost manufacturing of lightweight composites and alloys, aligning with global trends in sustainable aviation. We need more well-funded research institutions that will offer specialized training in Materials engineering to facilitate knowledge transfer and highly skilled personnel to lead advancements and research.

Raymond Otieno Amolo, 23
Kenyatta University
Bachelor of Science, Civil Engineering
Year Of Study: 5th Year

Fiber Reinforced Concrete (FRC) is a high-performance composite material formed by incorporating discrete, uniformly distributed fibrous materials into conventional concrete to improve its mechanical and durability characteristics. These fibers bridge micro-cracks and enhance tensile strength, toughness, ductility, and resistance to stress, addressing concrete's inherent brittleness. FRC is increasingly used in pavements, industrial flooring, tunnels, precast elements, and seismic zones.

It comprises cement, water, fine and coarse aggregates, and fibers such as: Fibers include: Steel (high tensile strength), Polypropylene (corrosion resistance, shrinkage control), Glass (for architectural use), Synthetic fibers (nylon, polyester), Natural fibers (coir, jute), Asbestos (chemical and thermal resistance), and Carbon fibers (very high modulus and flexural strength).The fiber content is measured by volume fraction (VF), typically ranging from 0.1–3%. The fiber aspect ratio (length/diameter) critically influences performance, with optimal behaviors observed up to a ratio of 75.

FRC enhances: Benefits include: Load distribution, Flexural capacity, Energy absorption, Crack control, and post-crack load resistance. It improves durability by resisting: Freeze-thaw cycles, Chloride intrusion, and Abrasion. Polypropylene fibers improve fire resistance by relieving vapors pressure. However, challenges include high cost, reduced workability, fiber clumping, corrosion risk, and absence from some design codes.

Mixing must ensure even fiber dispersion to prevent segregation. Performance depends on matrix-fiber stiffness contrast. High-modulus fibers (steel, carbon, glass) impart strength, while low-modulus fibers (polypropylene, nylon) offer impact resistance. FRC is a key material for sustainable, high-performance construction.

Student Voices

Derric Munene Muthii, 22
Kenyatta University,
Bachelor of Science in Aerospace Engineering
Year of Study: 5th Year

Materials are the silent architects of innovation. I have embraced this philosophy throughout my academic journey, grounding my expertise in science that empowers aerospace engineering. This belief has been the cornerstone of my university experience, laying a strong foundation in material engineering through courses in material science, solid mechanics and engineering materials. These Units enhanced my understanding of the mechanical behavior, microstructure and performance of aerospace-grade metals such as aluminum, titanium and steel alloys. Practical sessions in the engineering workshop further reinforced my knowledge of critical alloy processing techniques including heat treatment, machining and welding which are crucial in fabricating aircraft components such a fuselage panels, spars and landing gear brackets. Participation in multidisciplinary projects further built my practical skills and industry preparedness. While designing a Nox- mapping fixed wing drone, I contributed to the selection of aluminum 7075-T6 alloy for the fuselage and wing spars due to its high strength to weight ratio. In another project involving a crack monitoring system, we studied crack propagation in high strength steel alloys used in landing gear.

Guidance from professors and industry mentors have been pivotal. Through project supervision and demonstrations, I gained insight into material behaviors under aeroelastic stresses, vibrations and thermal gradients. On the industry front, a successful attachment at a local airline exposed me to use of advanced alloys including Ti-6A1-4V in compressor blades, nickel-based super alloys in turbine hot sections, steel alloys in actuators and control rods, aluminum alloys in skin panels and hybrid composite in cabin interior. Among the most exciting developments is the rise of aluminum scandium (Al-Sc) alloys for use in cryogenic tanks, rotor blades and actuators. Their microstructural refinement enhances fatigue resistance and structural integrity without increasing weight which is critical in development of lightweight and high-strength structures.

Material engineering is indeed indispensable in aerospace engineering as it directly influences aircraft safety, fuel efficiency and technological advancement. For prospective students, it offers a unique opportunity to contribute to cutting edge advancements in aviation and space exploration. Aerospace engineering stands out due to its interdisciplinary nature and its pivotal role in developing technologies that shape modern transportation and defense. As the aerospace sector grows, new challenges in material engineering may arise from the shift towards supersonic and hypersonic propulsion requiring ultra-high temperature alloys. These challenges also offer an opportunity for research and development, positioning Kenya as a potential competitive player in development of novel alloys for regional aerospace needs.

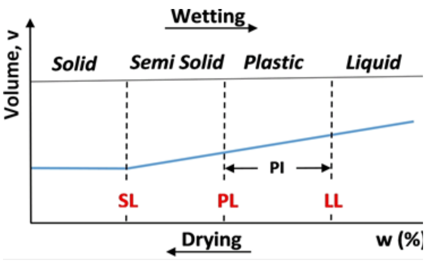
James Karanja,
Kenyatta University,
Email: jimkamaina019@gmail.com
Civil Engineering,
Year of Study: 5th Year

Long before concrete is poured or the first steel bar is set in place, the ground asks a quiet but weighty question: Are you sure about this, engineer?

In civil engineering, we learn quickly that confidence must be earned not just through calculations and codes, but through a careful reading of the earth itself. For while beams and columns will follow design assumptions obediently, soil has a more independent spirit. It behaves according to principles, yes, but also with peculiar tendencies that defy textbook expectations.

Nowhere is this more evident than with expansive clays. These fine-grained soils, laced with montmorillonite, are infamous for their ability to absorb moisture and expand, often with enough force to lift a foundation by several millimeters or more. During the dry season, they shrink back, leaving voids beneath slabs and gaps around footings. The result is rarely dramatic, but always insidious: differential movement, hairline cracks that grow with time, and the slow unravelling of what was once considered stable.

A soil's plasticity index (PI) becomes your early warning system. Anything above 20% calls for attention. A PI above 35%? This is now not just a red flag- it's a formal invitation to revise your design, possibly with a stiff drink in hand.

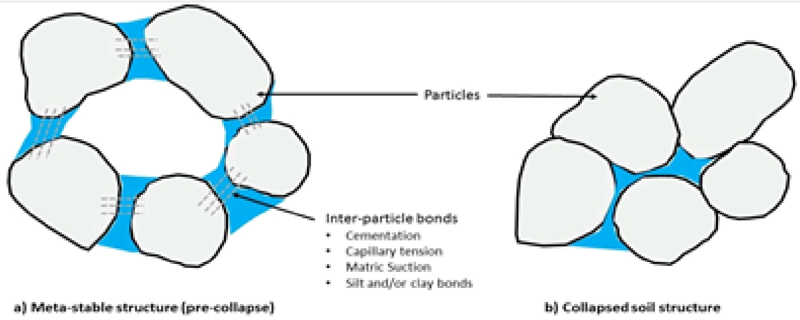


Student Voices

Then there's the deceptive calm of collapsible soils. Dry, they appear competent- sometimes even strong enough to bear modest loads. But introduce water, and their loose, open structure collapses, resulting in sudden, sometimes catastrophic settlement. This behaviour is typical of aeolian silts and poorly cemented sands, particularly in arid and semi-arid regions. Unlike expansive soils, which telegraph their movement through gradual swelling and shrinkage, collapsible soils prefer to keep their secrets until the structure is already in place.

The response, as always, lies in good investigation and better judgment. Geotechnical reports must never be treated as a formality. Boreholes should reach well beyond the foundation depth- ideally until a consistent stratum is observed. In situ tests like the Standard Penetration Test (SPT) offer insights into relative density and potential collapsibility, while lab testing (Atterberg limits, triaxial compression, consolidation tests) fills in the mechanical behaviors profile.

Once the nature of the soil is known, the countermeasures become clear. Expansive soils can be mitigated through:



i. Deep foundations, such as piles or drilled shafts, that transfer loads below the active zone.
ii. Raft foundations, which distribute structural loads evenly and reduce differential movement.
iii. Soil replacement, when practical, using compacted granular material to improve bearing capacity.
iv. Lime or cement stabilization, to chemically alter the soil structure and reduce plasticity.

For collapsible soils, pre-wetting and dynamic compaction may be employed to preempt settlement, or structural slabs designed to tolerate movement without distress.
It's tempting to assume that the visible structure is the measure of a project's success, but time teaches another lesson: what lies beneath is just as important. Soil does not fail dramatically. It whispers. It shifts slowly, until one day the cracks appear- and by then, the fix is expensive, intrusive, and rarely elegant.
So, we learn to listen. To measure twice, build once, and remain just suspicious enough of every "firm-looking" soil profile. Because in the end, engineering is not about imposing order on nature- it's about understanding when nature is likely to push back, and designing accordingly.

Because while the world may praise what rises, truer engineering wisdom respects what lies beneath.

Fellistus Gacheri,
Kenyatta University,
fellygache@gmail.com
Bsc (Civil Engineering)
Year Of Study: 4th year, attachment

Steel plays a vital role in building modern infrastructure, and in Kenya, its significance continues to rise. From roads and bridges to affordable housing and mega transport projects, steel remains at the core of national development. As a civil engineering student, I see first-hand how deeply the construction industry relies on this essential material.

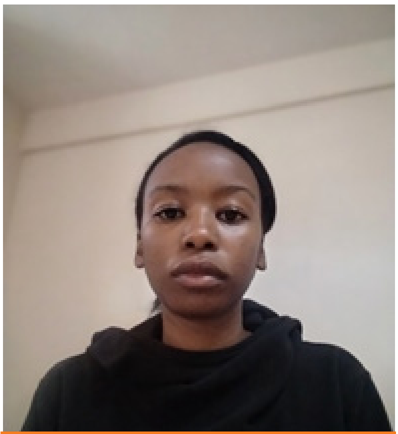
Kenya's steel journey began post-independence through import substitution strategies that established industries like stainless steel tank manufacturing and automobile assembly. However, limited competitiveness and weak implementation hindered long-term success. Today, the local steel industry primarily relies on scrap-based induction furnaces, lacking integrated steel mills and advanced processing facilities.

The construction sector remains the largest consumer of steel in Kenya, driven by rapid urbanization, population growth, and infrastructure development. Projects like the LAPSSET Corridor, Standard Gauge Railway, and the Affordable Housing Program, targeting 500,000 housing units, are pushing steel demand to record highs. In 2014, steel demand stood at 1.6 million tons, with projections indicating a rise to 4.4 million tons by 2030.

Despite this growth, Kenya's production capacity remains low; around 440,000 tons of liquid steel annually. The country continues to depend on imports, particularly hot-rolled coils, which limits self-sufficiency and increases costs. However, expansion plans by companies like Devki Steel Mills and interest in exploiting local iron ore deposits in Taita Taveta show promise for the future.

As the construction industry grows, so does the need for diverse steel products; rebar, tubing, structural beams, and coated sheets. Meeting this demand locally presents an opportunity for Kenya to boost its industrial base, reduce import reliance, and create jobs. Sustainable investment in energy-efficient technologies, training, and local raw material processing will be crucial.

Steel isn't just a material; it's a foundation for Kenya's structural and economic transformation.



Esthertshilla Mugendi
Kenyatta University,
esthermugendi1@gmail.com,
Year Of Study: 3rd Year

Kenya is rapidly expanding its electricity access, yet solar remains underexploited despite its ability to meet the country's energy demands. However, materials science, a cornerstone on which the efficiency and effectiveness of solar technology is held, is crucial to making it locally sustainable.
Materials science informs selection and optimization of materials for photovoltaic cells, thermal solar collectors and energy storage. Advances in materials such as from crystalline silicon to perovskite have led to gains and cost reductions globally.
Materials science plays a role in the following main areas; creating and improving light absorption and conversion materials like silicon, perovskites; influencing materials for collection and transport of charge; determining materials for protection and encapsulation as well as energy storage.

Kenya currently relies on solar technology to achieve off-grid electrification in a bid to meet its vision of universal electrification. Obstacles that have been identified to limit adoption of solar energy include high installation costs as a result of imported panels and batteries which have deterred low-income households from its adoption. Moreover, and perhaps more excruciating, is its direct contribution to limiting extent of local manufacturing making the country dependent on imports. The result has been a decline in solar energy materials expertise, aside from the problem of few research programs focusing on solar materials locally.
To leverage materials science knowledge and boost solar technology uptake, Kenya should incentivize local manufacturing. There should be funds for materials science labs at Kenyan universities to develop region-adapted solar materials. Moreover, quality standards should be strengthened to ensure standard equipment and build better adoption.

Materials science and solar energy systems are a key point in driving the transition to sustainable energy solutions. Local innovation in materials will inevitably lead to an affordable, reliable, and sustainable solar future.