Abstract book

Sustainable Construction in Africa (SCA25) Conference | Nairobi, Kenya |

20-22 May 2025

Editors
Alice Titus Bakera
Joseph Mwiti Marangu
Karen Scrivener

Organisers

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Edited by:

Alice Titus Bakera, University of Dar es Salaam, Tanzania and LMC EPFL, Switzerland
Joseph Mwiti Marangu, Meru University of Science and Technology, Kenya
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Organised by:

Laboratory of Construction Materials (LMC), École Polytechnique Fédérale de Lausanne (EPFL), Switzerland
Meru University of Science and Technology, Kenya

Editorial

This collection gathers the abstracts of all the articles submitted and presented at the Sustainable Construction in Africa 2025 (SCA25) conference, held in Nairobi, Kenya, from 20 to 22 May 2025.

SCA25 is a landmark event dedicated to addressing the pressing challenges and opportunities in Africa's built environment. Organised by the Laboratory of Construction Materials (LMC) at the École Polytechnique Fédérale de Lausanne (EPFL) under the supervision of Prof. Karen Scrivener, and the Meru Institute of Science and Technology, led by Dr Joseph Mwiti Marangu, this conference brought together leading voices from academia, industry, government, and civil society to promote affordable, scalable, and sustainable construction across the African continent.

The conference theme—"Sustainable Construction in Africa"—reflects the urgent need for innovative and context-specific solutions to support Africa's rapid urbanisation and infrastructure demands. While the conference covers a broad spectrum of topics related to construction technologies, materials, and implementation strategies, a strong emphasis has been placed on sustainability, affordability, and local resource utilisation.

More than 50 peer-reviewed papers, each with 10 to 15 pages, were accepted and presented at the conference. The papers encompass various innovative research on sustainable building materials. This includes Supplementary Cementitious Materials (SCM), admixtures, recycled materials, earth- and bio-based materials, bricks and blocks, and construction materials' structural and durability performance. Furthermore, it addresses urban housing concepts, challenges, and best practices that provide sustainable solutions for construction.

In addition to the technical sessions, participants were involved in expert panel discussions and exhibitions designed to promote cross-sector collaboration, enhance regional capacity-building, and establish practical standards, policies, and regulations for sustainable construction.

We were thrilled to welcome participants and sincerely thank all contributors for their high-quality submissions and commitment to sustainable development.

We hope the conference is a lasting resource for advancing sustainable construction practices and collaborations in Africa and beyond.

SCA25 Organising Committee

www.sca25.org

ISBN: XXX-X-XXXXXXX-0-0

DOI: XXXXXXXXXXXXXXXXX

Published by

Laboratory of Construction Materials (LMC),
Ecole Polytechnique Fédérale de Lausanne (EPFL),
Station 12
1015, Lausanne, Switzerland
https://www.epfl.ch/labs/lmc/

Cover Design

Laboratory of Construction Materials (LMC), Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland

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Ecole Polytechnique Fédérale de Lausanne (EPFL), Swirtzerland
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Effect of Binary Blend of Sorghum Husk Ash and Glass Powder as Partial Replacement of Cement in Pervious Concrete Production

Murtadha A. Tijani1*, Kayode J. Opadotun1, Waliu O. Raifu1 and Wasiu O. Ajagbe2

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Abstract. The increasing demand for concrete in infrastructure construction has led to a rise in Portland cement production, raising sustainability concerns due to high carbon emissions and resource consumption. To address these issues, using alternative materials can help reduce environmental impact. In Africa, urbanization has led to substantial solid waste, some of which can serve as partial cement replacements in concrete. This study focused on enhancing Pervious Concrete (PC) sustainability by incorporating sorghum husk ash (SHA) and glass powder (GP) as a binary cementitious material (BCM). Different PC mixtures were prepared with BCM replacing 0% (0%SHA+0%GP), 10% (5%SHA+5%GP), 20% (10%SHA+10%GP), and 30% (15%SHA+15%GP) of the cement. The density, compressive strength, abrasion resistance, and hydraulic properties (porosity and permeability) of the BCM samples were assessed after 28 days, following ACI standards. Additionally, the sustainability of incorporating BCM into PC mixtures was evaluated by estimating embodied energy and carbon emissions. The results revealed that incorporating BCM led to a reduction in the density of PC mixtures. The mixture with 10% BCM replacement was identified as optimal, as it improved compressive strength and abrasion resistance while maintaining satisfactory porosity and permeability. The sustainability analysis showed that embodied energy and carbon footprint of PC mixtures reduced with increase in BCM. The maximum reduction of embodied energy (31.1%) and carbon emission (25.5%) were obtained at 30% BCM replacement. The findings of this work offer a sustainable path to recycle SHA and GP for constructions.

Keywords: Binary Cementitious Material, Cement, Concrete, Glass powder, Sorghum husk ash, Sustainability.

Preliminary Study on a Performance-driven Mix Design Approach for Geopolymer Mortar

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Abstract. The construction industry increasingly focuses on sustainable materials, and geopolymer technology is a promising alternative to conventional cement-based materials. It employs industrial or agricultural by-products or wastes to reduce the environmental footprint of construction. Despite significant progress in geopolymer research, it remains challenging to optimize its mix design due to the complex interaction between precursor materials and activators. Considering this challenge, this study introduces an improved and customized mix design methodology for geopolymer mortar mix proportioning through theoretical formulation based on the specific chemical compositions of precursor materials and activators such as sodium hydroxide and sodium silicate. Results from the mortar testing indicate promising performance, with compressive and flexural strengths reaching 68.25 and 9.63 MPa, respectively, after an initial 24 hours of oven curing followed by 28 days of ambient curing, comparable to conventional geopolymer mixes. These mortar mixes demonstrated workability ranging from 70% to 145%, densities between 2117 and 2220 kg/m^3 and water absorption values from 4.47% to 5.27%. These results indicate that the mixes are suitable for structural and non-structural applications. Hence, they provide a solid foundation for scaling to full-scale geopolymer concrete. In addition, the mix design methodology offers an innovative framework adaptable to different local pozzolanic material compositions. Likewise, it contributes to the growing body of knowledge needed for the broader adoption of geopolymer technology in Africa.

Keywords: Geopolymer Mortar, Geopolymerization, Mix Design, SiO_2/Al_2O_3 Ratio, Na_2O/SiO_2 Ratio.

Investigating the Viability of Gold Tailings as a Partial Cement Replacement in Concrete

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Abstract: The cement construction industry is responsible for approximately 8% of total carbon dioxide emissions worldwide, leading to increasing environmental concerns considering greenhouse gases' contribution to climate change. As a result, there is significant pressure on the construction industry to adopt eco-friendly materials and practices to support the increasing infrastructure demands in Africa. One approach for sustainable construction is the use of industrial by-products such as supplementary cementitious materials in concrete: it reduces the clinker demand and reduces waste being dumped in landfills. The mining sector produces numerous tailings based on the minerals being mined, which have the potential to be used within the construction industry. In this study, specific interest has been directed to gold tailings owing to their availability in the Gauteng region. This paper reviews the feasibility of integrating gold tailings, by-products of gold extraction processes, in various construction industry applications. Lastly, this study presents the results of a series of tests that have been conducted to characterize concrete produced using mechanical, thermal, and chemically activated gold tailings as partial cement replacement in concrete. The gold tailings were sourced from a gold mine east of Johannesburg in Brakpan, South Africa.

Keywords: gold tailings, circular economy, partial cement replacement

Durability of Rice Husk Ash Concrete - An Investigative Report

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Abstract. Agricultural wastes in the form of Rice Husk Ash (RHA) from the calcination of rice husks have been established as a suitable additive for cement to achieve sustainable construction. There is however little research on the durability characteristics of RHA concrete. This report intended to fill that gap by exposing concrete samples made from CEM I and CEM II cement types and infused with RHA from the Mwea region in Kenya, to various exposure conditions over a period of 90 days. The conditions were namely sulphuric acid (H_2SO_4), hydrochloric acid (HCl), carbonic acid (H_2CO_3), seawater, UV light and normal portable water. The results analysed through a Performance Index (PI) showed that an increase in RHA content in concrete samples resulted in an improvement of the physical properties (through change in weight) and mechanical properties (through compressive strength tests). These findings, specifically CEM II cement, showed that the physiochemical properties of a particular cement type, as well as the RHA, are a contributing factor to getting improved results. The feasibility of RHA as SCM against the common delirious agents in the environment is in the end a step towards sustainable construction.

Keywords: RHA, Concrete Durability, Supplementary Cementitious Materials, Sustainability, Performance Index.

Linking calcination and reactivity in Kenyan Rice Husk Ashes as supplementary cementitious materials

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Abstract. Sustainable construction practices are necessary for environmental protection. Agricultural wastes such as rice husks can be calcined to produce Rice Husk Ashes (RHA) rich in amorphous silica that can then be used as supplementary cementitious material (SCM). Its key utility is the pozzolanic reaction that consumes excess portlandite from the hydration reaction. RHA usage as SCM has been thoroughly reviewed, and in particular the relation between calcination and pozzolanic reactivity. However, most studies remained empirical or based on macroscopic properties and chemical analysis. Here, we attempt a mechanistic study of the calcination process and of the pozzolanic activity of the RHA. On a series of samples of Kenyan RHA calcined under well-controlled conditions, we used a series of molecular characterizations (X-Ray Diffraction, Infrared Spectroscopy, Thermo-gravimetric Analysis), as well as microscopies. The Frattini Test was then carried out on various cement-RHA blends to determine the level of pozzolanic reactivity after 7,14 and 28 days. The ultimate goal was to understand the link between RHA calcination conditions and reactivity to optimize RHA production as SCMs in sustainable cements.

Keywords: Cement chemistry, Rice Husk Ashes, Supplementary Cementitious Materials.

Use of the volcanic ash cement replacement for concrete block – impact on the workability and the compression

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Abstract. Cameroon has abundant unused and un-mastered resources in the construction field. This is the case of volcanic ashes. Indeed, volcanic ashes found in the grand west of the country and they are used in the region in artisanal way. They are used mainly as sand replacement and additionally as cement substituent in concrete block production. This study intends to bring a good understanding of the volcanic ashes on the performance of concrete blocks. To do this, various portions of cement was gradually removed from a common mix design used for the concrete blocks, with a constant amount of water and sand. The results show an optimum mix design at 20% of replacement of cement. At this point, the compression strength is at its maximum and the cementitious paste is more workable than the paste without ashes. The increase of the compression can be correlated to the use of volcanic ashes as fine aggregate, while the increase of the workability related to the increase of the water:cement ratio (due to the decrease of cement). Further studies will be carry out to characterize the volcanic ashes, especially its pozzolanic activity.

Keywords: Volcanic ashes, Concrete blocks, Material replacement.

Valorizing a coal combustion byproduct with high carbon content and coarse particle sizes

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Abstract: Off-spec coal combustion byproducts, CCBs are those in which their chemical or physical properties do not meet the requirements of standard specifications. These are one of the main industrial byproducts which go to landfills and cause environmental pollution. In the study attempt was made to investigate the functionality or applicability of these kinds of CCBs in a concrete production. For this purpose, experimental investigations were conducted to assess the potential of the CCBs, with high carbon content and coarse particle sizes, in replacing some amount of the cementitious material. The ash was investigated by X-ray diffraction, scanning electron microscope and its physical and chemical properties were also examined. The coal ash was used in making concrete by three different waters to binder ratios (0.4, 0.5 and 0.6) and four percentages (0%, 10%, 15% and 20%) of volumetric replacement of the cement. The coal ash containing concrete samples were tested for their compressive strength development and their long-term performance in an acidic medium. The results indicated that utilization of the coal ash have caused reduction in the compressive strength. However, based on mass loss measurement, the addition of coal ash has enhanced the resistance of concrete against acid attack. Thus, the study has elucidated the two-fold benefits. One is the possibility of applying such kind of coal ash in making concrete that can be used in aggressive environments and need moderate strength. And the other is the possibility of valorizing the waste and reducing the environmental impact of the landfill.

Keywords: Off-spec coal ash, Sustainability, acid resistance

Polysaccharide-Based Admixtures for Rheology Control in Low Carbon Concrete

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Abstract. The expected construction boom in the global South and the widespread use of concrete, driven by a rapidly expanding population, will become a major contributor to global CO_2 emissions if business as usual technologies continue to be applied. To mitigate the environmental impact, the concrete industry must urgently adapt greener technologies and improve cement efficiency. This challenge is particularly acute in regions like Africa, where high cement prices necessitate efficient resource management and rapid urbanization demands innovative and novel, local solutions.

For better resource management, substituting ordinary Portland cement with supplementary cementitious materials (SCMs) is a promising solution; however, this approach often brings challenges related to the properties of fresh concrete. Thus, using chemical admixtures to manage binder performance and rheological properties is crucial. Superplasticizers effectively reduce the water-cement ratio while improving rheology. However, in Africa, challenges arise from inadequate supply chains and a lack of local production facilities for these chemicals.

This paper presents case studies on organic admixtures that serve as a viable alternative to conventional synthetic polymers, offering innovative and efficient solutions derived from locally sourced plant-based biomaterials. With 60% of the world's unused arable land located in Africa and tremendous potential to increase the hectare yield, the region holds significant potential for bio-based concrete components derived from agricultural materials and by-products.

Keywords: Rheology, polysaccharides, chemical admixtures, yield stress, workability.

Calcined clays as the most appropriate Supplementary Cementitious Material (SCM) for pozzolanic Portland cement in Africa: A comparative study with volcanic pozzolans

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Abstract. To reduce the use of Portland clinker in cement for environmental concerns, various Supplementary Cementitious Materials (SCM) are substituting Portland cement clinker in Portland cement mixes. Natural volcanic pozzolan is common SCM applied in several African countries for this purpose. In the present study, powders of less than 100 µm of three (03) volcanic ashes or scoria from volcanic origin and two (02) calcined clay samples were subjected to chemical analysis, BET specific surface, absolute density, granulometry and pozzolanic activity tests. The results obtained showed that, samples contain significant amounts of glassy or amorphous phase ready to dissolve in hydrated lime solution, but the high alkali content of volcanic pozzolans makes them not appropriate for pozzolanic Portland cement application. In fact, ASTM C-618 recommends the following compositions for SCM used as additives in cement (class N): $SiO_2 + Al_2O_3 + Fe_2O_3$: 70.0% minimum, SO_3: 4.0% maximum, MgO: 5.0% maximum, Na_2O: 1.5% maximum, Loss on ignition: 10.0% maximum. On the other hand, calcined clay samples were chemically and physically the most appropriate SCM for pozzolanic Portland cement. In addition, they were easier to grind in order to achieve the appropriate fineness with benefits in grinding energy saving. Since clay is almost present in all African counties, it uses as SCM after appropriate calcination is an opportunity for greener Portland cement production.

Keywords: Pozzolan, Volcanic pozzolan, Calcined clay, Characteristics, Supplementary Cementitious Materials, Low carbon cement.

Utilising locally sourced indurated laterite and low-grade clay from Cameroon as supplementary cementitious material: Case of Limestone Calcined Clay Cement (LC3)

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Abstract. The growing urbanization, rising population, and expanding economies drive the demand for more housing and durable infrastructure in developing nations. Incorporating blended cement with supplementary cementitious materials is the most effective method to reduce the carbon footprint of cement-based products significantly. This has increased interest in investigating Limestone-Calcined Clay Cement (LC3). This study explores the potential use of indurated laterite as supplementary cementitious materials from Cameroon in producing LC3. In this study, reactivity test R3 was performed according to the ASTM standard C1897 on calcined laterite. Also, the hydration kinetics, such as calorimetry and XRD Rietveld analysis and the strength of the LC3 system with 50% clinker were investigated. The R3 test revealed that the calcined laterite had a reactivity of approximately 680 J/g. The compressive strength of the LC3 blend with 30% substitution of calcined laterite had a compressive strength comparable at 90% to OPC at 28 days. Results showed that laterite can be used as a supplementary cementitious material in producing LC3. The present data will be displayed on the hydration of the laterite-based blended cement but also show new results on a model system setup investigating the intrinsic reactivity of the calcined laterite.

Keywords: calcined laterite, hydration, compressive strength, limestone calcined clay cement (LC3).

Influence of polokwane platinum slag aggregate on the strength properties of portland cement-based concrete

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Abstract. The world stands at a crossroads with natural resource preservation and global development. Urbanization necessitates efficient use of natural resources and responsible waste disposal. Using waste materials in concrete production is an efficient solution to overdependence on natural resources and holds potential for sustainable construction. This study focuses on using Polokwane platinum slag aggregate (PSA) as a fine aggregate in concrete production. The aggregate was milled to fine aggregate particle size and was used to replace Malmesbury sand (MS) at 0%, 25%, 50%, 75%, and 100% in Portland cement (PC)-based concrete. Mechanical properties of the water-cured concrete specimens, such as compressive, flexural, and splitting tensile strengths were investigated. The workability was evaluated using a slump cone test, and the morphology examined through scanning electron microscopy (SEM). The concrete slump was enhanced with increasing PSA content. The compressive strength of the 25% PSA specimen is similar to the control specimen (48.3 MPa) at the 28-day, while the strength decreased by 10.9%, 18.4%, 20.3% at 50%, 75%, and 100% PSA replacement contents, respectively. The flexural strength at all replacement levels, including the control, is approximately the same at 28 days (5 MPa), while the 25% and 50% PSA enhanced the splitting tensile strength (28 days) by 8.8% and 5.9%, respectively. At 75% and 100% PSA, the splitting tensile strength decreased by 5.8% and 2.9%, respectively. Conclusively, PSA could replace natural sand by up to 50%. Using PSA holds the potential for cost reduction, environmental protection, resource preservation, and sustainable construction while maintaining the strength of the concrete.

Key words: Sustainability, Polokwane platinum slag aggregate, mechanical properties, Portland Cement, concrete.

Potential implications of lateritic clays from the upper geomorphological domain of Mbé (Adamawa-Cameroon) for a sustainable building construction

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Abstract. The objective of this study is to identify and characterise the weathering materials of Mbé in order to determine their origins and their implications for the earthen construction sector. Four samples were collected to evaluate the physicochemical and mineralogical parameters. The materials under investigation are mainly composed of gravel (11.8 and 38.6% by weight), sand (24.7 and 44.8% by weight), silt (4.5 and 17.3% by weight) and clay (12.3 and 30.7% by weight). The samples display medium plasticity (PI, 16.4-18.1%) and methylene blue values (2.5-3.1 ml/g) comparable to those of silty-clay soils. These materials are classified as gravelly-textured, clayey soils according to the international classification systems (USCS, HRB, and GTR). The samples are characterised by a high concentration of SiO_2 (41.61-53.94 wt%), Al_2O_3 (15.56-20.1 wt%), and Fe_2O_3 (3.83-9.42 wt%), with relatively low levels of other oxides (10 wt%). The most prevalent mineralogical constituents of these weathering materials are clay minerals, including kaolinite, illite, and chlorite, as well as non-clay minerals such as quartz, muscovite, biotite, gibbsite, and hematite. The materials examined can be used in the production of earth bricks and ceramics, according to various graphic criteria. The main mechanisms responsible for forming these materials are monosialitisation and bisialitisation. These mechanisms influence the proportions of minerals in the weathering materials and are dependent on the geomorphology of the site.

Keywords: Weathering materials, Mbé, physico-chemical, mineralogical, earthen construction.

Effects of pyro-processing on hydration reactivity of a locally sourced clay for potential use as a supplementary cementitious material in concrete

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Abstract. This study investigates the use of locally sourced clay as a supplementary cementitious material (SCM) in concrete. This is motivated by the need to reduce the Portland cement (PC) content of cement binders, thus lowering the carbon footprint of cement production while promoting sustainable construction practices within the circular economy framework. Limestone Calcined Clay Cement (LC^3) emerges as an innovative cement that significantly reduces CO_2 emissions by incorporating a lower proportion of clinker in its production process. In this study, a sample of clay from a site in Johannesburg, South Africa was assessed for potential use in LC^3. The reactivity of clay increases with heating temperature. In this study, three samples of clay were each heated to a maximum temperature of 600ºC, 700ºC, and 800ºC respectively. For each peak furnace temperature, the clay samples were subjected to three different cooling rates to room temperature. This was done to determine the effect of different pyro-processing regimes on the reactivity of the clay. Samples of the heated clays were separately cooled in the furnace, cooled in air after removal from the furnace, and quenched with water. The untreated clay was characterised using XRF, and TGA. After pyro-processing in the furnace, three cementitious binder blends were prepared: (a) 100% PC; (b) 50% PC + 15% limestone + 35% fly ash, and (c) 50% PC + 15% Limestone + 35% calcined clay, using all nine of the calcined clay samples produced. The reactivity of the resulting binders was assessed by measuring the compressive strength of mortar cubes prepared at a w/b ratio of 0.50.

Keywords: LC^3, Clay, Green Concrete, Pyro-processing, Hydration Reactivity, Sustainability.

Experimental Evaluation Of Limestone, Calcined Clay And Cement (LC3) Using Limestone, Calcined Laterite, Kaolin, Sand And Rice Husk Ash (RHA).

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Abstract

This study seeks to analyze the conventional supplementary cementitious materials of the samples produced in the laboratory from limestone, calcined laterite, kaolin, sand and rice husk ash (RHA). The rice husk was sourced from a small-scale rice production factory at Ejisu in the Ashanti Region of Ghana. The processing of these materials was carried out in the laboratory. A pyrolysis system was used for the calcination of the limestone at a temperature of 900 degrees, the rice husks into Ash at a temperature range between 500 to 700 degrees Celsius and Laterite in the temperatures of 500, 600 and 700 degrees Celsius respectively. Physical test of the batch prepared mix was carried out. The samples were moulded and cured for 28 days.

Preliminary analysis such as compressive strength, XRD, XRF, UPV and water absorption test of the constituent materials were conducted to confirm their sustainability for the production of the specimen. The use of these materials as SCMs was to reduce the CO2 emissions from cement production. The utilization of these materials in cement production can partially reduce the consumption cement, which, in turn, can lessen construction costs, providing materials suppliers, contractors and engineer with substantial advantages.

Strength properties of recycled aggregate Limestone Calcined Clay Cement concrete

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Abstract. Significant construction is yet to be experienced in Africa due to a lack of massive urbanisation and industrialisation. However, these construction activities rely heavily on structural concrete, which constitutes cement as one of the main input materials. The major challenge with cement is that for every tonne of cement produced, nearly an equivalent amount of carbon dioxide is emitted into the atmosphere. Additionally, cement production is an energy-intensive process. Limestone calcined clay cement (LC3) has emerged as an environmentally friendly and energy-efficient cement substitute. Notwithstanding, its viability based on mechanical performance assessment using locally available material constituents still needs to be elucidated. In this study, the quasi-static performance of LC3 mixes containing 25%, 50%, and 100% recycled fine aggregate (RFA) from construction and demolition waste was assessed and compared with conventional concrete. Overall, the results indicate that LC3 concrete has compressive strength, flexural strength, and modulus of elasticity comparable to conventional concrete. RFA-LC3 concrete mixtures perform similarly or better than conventional concrete. These results suggest that the combination of LC3 and RFA could be instrumental in executing sustainable construction in Africa.

Keywords: Limestone calcined clay, recycled fine aggregate, compressive strength, flexural strength, modulus of elasticity.

Physico-mechanical properties of cement containing calcined clay and slag from the recycling of metal scraps: feasibility towards low-carbon cement in Burkina Faso

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Abstract. This study assesses the performances of a ternary cement containing ordinary Portland cement CEM I (C) partially substituted, up to 30%, by metakaolin calcined clay (M) and furnace slag (S). Using slag as a substitute for metakaolin would reduce energy consumption in cement manufacturing and optimize its cost. Although the slag tends to reduce the compressive strength of cement, the substitution up to 15:15 % M:S would allow it to reach similar performances as ordinary Portland cement. The combination of the reactivity effect of calcined clay and the filler effect of slag is beneficial to other physical properties, such as water demand to normal consistency and setting time of cement pastes, as well as the workability of the cement mortar in this ternary composition. This constitutes a step toward the future development of low-carbon cement in the local context.

Keywords: furnace slag, calcined clay, ternary cement, physico-mechanical property

Enhancing Early-Age Compressive Strength of High-Volume Calcined Clay Oil-Well Cement with Rice Husk Additives for Improved Performance and Sustainability

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Abstract. This study explores the impact of high-volume calcined clay (CC) and rice husk additives on the early-age compressive strength of Class G oil-well cement. The aim was to enhance the strength of CC-modified cement by incorporating raw rice husk powder (RHP), alkali-activated rice husk powder (ARHP), and rice husk biochar (RHPB). Five slurries were prepared: pristine Class G cement (GC) as control, 40% calcined clay by weight of cement (40%CC), 40%CC with 5% RHP (SN1), 40%CC with 5% ARHP (SN2), and 40%CC with 5% RHPB (SN3). The slurries were cured at 70°C in distilled water for 48 hours and tested for compressive strength. Life Cycle Assessment (LCA) was also performed. Results showed that 40% CC reduced the compressive strength of the control by 24%. However, SN1 and SN3 improved strength by 34% and 55%, respectively, compared to 40%CC, and by 2% and 18% compared to GC. In contrast, SN2 decreased strength by about 8% and about 30% compared to 40%CC and GC, indicating that SN2 formulation was not beneficial. LCA revealed SN3 achieved about 36% reduction in CO_2 emissions and 46.13% lower environmental impact factor compared to GC. These findings suggest that incorporating RHPB (SN3) provides an efficient utilization of rice husk wastes and a more sustainable solution for enhancing the early-age strength of oil-well cement, offering a promising alternative for environmentally friendly cementing applications.

Keywords: Calcined Clay, Compressive Strength, Life Cycle Assessment (LCA), Oil-well Cement, Rice Husk Biochar, Sustainability

Promising performance of straw block as climate resilient construction material

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AbstractThe negative impacts of the construction industry are compelling arguments to embrace technology that contribute to Carbon footprint reduction and resource conservation. As result, development of new building's materials like straw bale have evolved in construction industry. Straw bale is an eco-friendly material that presence advantages like provision of thermal indoor comfort and its contribution towards circular economy. However, it has some drawbacks like low compressive strength and high displacement under compression load. No attempt has been made in order to enhance straw bales' performance. This study aimed to develop alternative material to straw bale and investigate its potential. The manufacturing process of the new material involved, the use of chopped straw and gum Arabic. Water and thermal resistance, compressive strength of blocks as well as the structural performance of the assemblies made of straw blocks were tested. Results obtained show that plastered straw blocks assemblies can carry at least 286 KN/m^2 which is higher than the minimum slab load (18.2KN/m^2) for residential house. Moreover, the average thermal conductivity of straw blocks is 0.06W/m.K. Furthermore, it was recorded that the initial rate of absorption of straw block is in the range of 0.10-0.22 g/sq inch/min. This value is less than the limit value (1g/sq inch/min) recommended. From the above data, straw block is a potential building material for climate change adaptation. Its use for building construction will contribute towards energy efficient houses in hot climate where demand for cooling energy have increased due to extreme temperatures.

Key words: Thermal Insulation, Load Bearing Capacity, Initial rate of Absorption, compressive strength, bonding strength

Simultaneous Incorporation of Agricultural By-Products to Enhance Unfired Earth Bricks for Sustainable Housing in Malawi

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Abstract. The increasing demand for affordable and sustainable housing in Malawi and across Africa has led to a renewed interest in earth-based building materials due to their economic and environmental benefits. Despite their widespread use, little empirical research has investigated the mechanical performance of earth in local housing. This study investigates the mechanical properties of unfired earth bricks fabricated from soils sourced from three regions in Malawi and one from Japan. Agricultural by-products, sugarcane bagasse fibres and cassava peels, were incorporated as stabilizing agents in bricks made from Japanese soil to evaluate their reinforcing effects. Soils were characterized based on particle size distribution, mineralogical composition, chemical composition, and ionic conductivity. Properties of agricultural by-products analysed include density, water absorption and initial water content. The mechanical properties of bricks, including flexural and compressive strength, bulk density and volume shrinkage, were investigated. Results indicated that two of the three Malawian soils, along with the Japanese soil, surpassed minimum strength requirements for earth brick construction. In addition, bricks reinforced with agricultural by-products showed improved performance: flexural and compressive strength increased by 25% and 14% respectively compared to unstabilized bricks. Slight reductions of elastic modulus, bulk density and volume shrinkage by 4%, 3% and 2% respectively, with a significant reduction of 16% mass loss, were also observed. This research highlights the potentials of using multiple agricultural by-products to reinforce unfired earth bricks, and the need for further research into performance of earth building materials using locally available soils, agricultural by-products and wastes, contributing to the development of localised low-cost housing solutions.

Keywords: housing, sustainability, soil, sugarcane bagasse, cassava peels, mechanical properties.

Effect of wetting-drying cycles on the Alfa fibres stabilised compressed earth blocks

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Abstract. Compressed earth blocks (CEBs) present a promising sustainable construction material, yet their widespread adoption remains limited by critical vulnerabilities, particularly moisture susceptibility and insufficient mechanical performance. This study investigates the enhancement of CEBs through the incorporation of mineral binders and alfa vegetal fibres, focusing on performance under cyclic wetting-drying conditions. Specimens were prepared using local silty soil with varying lime and slag percentages, respectively (4%, 8%) and (4%, 8%, 12%), by dry soil mass, incorporating 20-25 mm long alfa fibres. The dry compressive strength, total absorption, and mass loss before and after 12 standardised wetting-drying cycles on 28-day cured specimens were determined. The results obtained demonstrate a significant improvement in dry compressive strength. An increase in strength of up to 30.12% after wetting-drying cycles is presented by (lime-slag) stabilised samples. Lower values, in mass losses in fibre-containing samples, are given by the stabilised ones with higher (lime-slag) binder content (up to 98.6% mass retention), compared to (up to 20.36% mass loss) for lower (lime-slag) binder content. These results show how a mixture in a precise proportion of natural alfa fibres and (lime-slag) binder can enhance CEB mechanical strength and moisture resistance, offering substantive insights for sustainable construction materials development, in areas where persisting dry seasons are followed by wet ones. A typical African climate condition.

Keywords: Compressed earth blocks, Moisture exposure, Alfa fibre, Wetting-Drying Cycles, Compressive Strength, Lime-Slag Stabilization

blocks for sustainable construction in the Soudano-Sahelian zone of Cameroon

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Abstract. The 2022 global status report for buildings and construction stated that this sector accounted for over 34% of the global energy demand and about 37% of energy and process-related CO_2 emission in 2021. The resultant figures are from the extraction of raw materials, transportation, industry, building operations, building materials and construction processes. Building materials contributed for about 9% of overall energy-related CO_2 emission. Hence, the need to decarbonize the sector. In the present study, lime-calcined clay (LC2) cement was elaborated, characterized and applied in the stabilization of compressed earth blocks for building. The objective of the study is to contribute to the substitution of Portland cement in compressed earth bricks stabilization by a lime-calcined clay binder. The raw materials used were from Garoua, a locality of the Northern Region of Cameroon, in the Soudano-Sahelian zone. The percentage of hydrated lime in the cement was 25%. Experimentations for the stabilization of earth blocks were done at the laboratory scale (using 800 and 900°C thermally activated expanding clay) and pilot scale (using fired clay bricks waste). Results showed that physical and mechanical characteristics of blocks obtained were more than the recommended by Cameroonian standards NC 102-114: 2002-06 for compressed earth blocks. LC2 cement contributed to about 58% reduction of CO_2 emission, only on raw materials calcination and about 40% on calcination temperature compared to ordinary Portland cement. Lime-calcined clay (LC2) cement stabilized earth blocks could be an ecofriendly alternative to Portland cement stabilization and vulnerable artisanal production of clay fired bricks in the Soudano-Sahelian zone of Cameroon.

Keywords: Low carbon cement, Lime-Calcined-Clay cement, Compressed Earth Blocks, Sustainable Construction, Soudano-Sahelian.

Investigating the Compressive Strength of Sisal-Reinforced High-Compressed Earth Blocks

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Abstract. The current research presents the results of an experimental investigation of the compressive performance of sisal-reinforced earth under high compression conditions. Developing alternative sustainable and environmentally friendly construction materials to conventional materials has become a fundamental research area. Compressed Unstabilized Earth Blocks (CUEBs), particularly, represent an eco-friendly alternative to the cement stabilized Compressed Earth Blocks (CEBs) while providing improved performance over traditional materials, predominantly utilizing earth. Sisal fibers are added to earth blocks to enhance their mechanical performance and serve as secondary reinforcements and crack arresters, hence minimizing the defects that are experienced when working with these blocks. In this experimental study, the earthen mixture is mixed with sisal fibers 0.5 %, 0.75 %, 1.0 %, 1.25 %, 1.5 %, and 2.0 % by weight of soil, respectively, in three batches of varying fiber lengths of 2 mm, 4 mm and 6 mm. The main goal of the study was to determine which fiber length and at what admixture content the best mechanical qualities after compressive strength testing would be achieved. The results obtained showed the combined effect of the sisal fibers and the high compression on the compressive strength properties of the CUEBs material. The findings indicated that the most effective configuration for attaining high-strength performance is the 6mm fiber length, while the optimum admixture proportion was found to be 1.25 % sisal admixture composition. However, both Modulus of Elasticity E_1 (Tangential Modulus) and E_2 (Secant Modulus) appeared to be optimized at lower admixture percentages (0.5 %-0.75 % sisal).

Keywords: Sisal fibers, Compressed Earth Blocks, Composite, Fiber Reinforced, Sustainability

Towards a performance-based approach in Kenya for the design of durable concrete mixes for steel reinforced concrete (RC) structures

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AbstractThere is a global paradigm shift in the approach used for the design of concrete mixes, from a prescriptive to a performance-based approach that aims to ensure sustainable construction with concrete. In this paper, a concise overview is made of an ongoing study that aims to propose the use of a performance-based approach in Kenya, particularly in the design of concrete mixes for steel reinforced concrete structures in marine areas. In this study, there are three research objectives. The first aimed at gaining an overview of the approach used for design of concrete mixes, and if durability is considered. This was done through interviews of various parties in the construction industry and a review of reports on bridge assessments carried out in the Coastal region of Kenya. The second objective was to fabricate the Oxygen Permeability Index (OPI), adapted from South Africa to determine the permeability (a durability indicator) of concrete mixes. The final objective involved an experimental study to determine the effect of the reduction of cement content with the use of Supplementary Cementitious Materials (SCMs) on concrete properties - its workability, compressive strength development and permeability. The SCMs used were Fly Ash (FA), Natural Pozzolana (NP), Rice Husk Ash (RHA) and Sugarcane Bagasse Ash (SCBA). From the experimental work, it was observed that for the 3 cement types considered, the performance of the biowastes (RHA and SCBA), was similar, and in some cases surpassed that of conventional SCMs (NP and FA).

Keywords: Steel reinforced Concrete, Sustainability, Performance-based design, durability, marine environment, supplementary cementitious materials (SCMs

Plastic Shrinkage Cracking of Limestone Calcined Clay Cement Concrete

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Abstract: Limestone calcined clay cement (LC^3) is a sustainable, environmentally friendly, and economical alternative to ordinary Portland cement (OPC). However, understanding the plastic shrinkage cracking behaviour of LC^3 is critical for its adoption in the construction industry. Beyond being aesthetically unpleasant, cracks can serve as pathways for the ingress of corrosive substances into the concrete and could shorten the lifespan of structures. This study investigates the plastic shrinkage cracking of LC^3 concrete under extreme and normal climatic conditions in a climate chamber. A concrete mix was prepared by substituting 30% of CEM I with limestone and calcined clay (LC^2) blend. The shrinkage and crack formation in the control (CEM I) and LC^3 mixes were monitored using the Digital Image Correlation technique. Results indicate that the crack area in the LC^3 mix was more than twice that of the control, highlighting the increased susceptibility of LC^3 to plastic shrinkage cracking. These findings suggest that precautionary measures are essential when using LC^3, particularly in regions prone to extreme climatic conditions.

Keywords: Limestone calcined clay cement, Plastic shrinkage, Plastic shrinkage cracking, Digital Image Correlation, Climatic conditions.

Carbonation of Concrete Cured Under Different Conditions

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Abstract. Concrete is cured under different conditions to preserve the moist state of the concrete matrix for continuous hydration as it is done on most construction sites. In this study, the effect of different curing techniques on the carbonation depth of concrete is presented. Concrete matrix of mix ratio 1 :2 :4 with water-cement ratio of 0.5 was prepared and cast into cubes of sizes 150 mm. After 24 hours, the concrete cubes were removed from moulds and cured using different techniques for 3, 7, 28, 56, and 90 days. Thereafter, the compressive strength of the concrete cubes and carbonation depths were determined for each curing day. The curing techniques investigated were ponding (PD), sprinkling (SP), polyethylene membrane (PM), damp sand (DS), indoor (IND), outdoor (OT), and saturated wet covering (SWC). The results indicated that carbonation depth differed with each of the concrete cured by different techniques. It was observed that concrete exposed outside (OT) was worst affected by carbonation followed by those cured indoor (IND), while those cured with polythene showed the least carbonation depth. It was concluded that the polythene membrane curing technique was the best curing technique to limit the effect of carbonation on concrete.

Keywords: Carbonation Depth; Curing Techniques; Permeability; Compressive Strength; Construction Site.

Investigating the impact of pre-treatment on recycled concrete aggregates for pervious concrete applications

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Abstract. Pervious concrete (PC) has gained popularity as a sustainable construction material due to its ability to reduce urban runoff by promoting storm water infiltration. Recycled concrete aggregate (RCA) is being explored as a substitute for natural coarse aggregate (NCA) in PC, offering an environmentally friendly alternative. This study investigates the effects of pretreating RCA on the properties of PC. Four pretreatment methods were applied to RCA: cement slurry coating (C-RCA), mechanical treatment (M-RCA), thermal treatment (T-RCA), and washing (W-RCA). The physical and strength properties of the aggregates were evaluated. PC mixtures were designed with the same aggregate size (4.75-9.50 mm) using NCA, untreated RCA (U-RCA), and treated RCA. The results showed that the specific gravity, water absorption, and aggregate crushing values (ACV) and aggregate impact values (AIV) of all aggregates fell within acceptable limits. The densities of PC ranged from 1785.13 to 2137.20 kg/m³. Pretreating RCA reduced the porosity and permeability of PC. At 28 days, the compressive strength (CS) of PC made with NCA, T-RCA, M-RCA, W-RCA, and C-RCA was 91.13%, 33.13%, 31.05%, 23.97%, and 11.07%, respectively, higher than that of U-RCA PC. All PC samples met the ACI 522R requirement of 2.8-28 N/mm². T-RCA PC exhibited optimal CS but with the lowest porosity and permeability values. This study demonstrates that pretreating RCA improves its properties, leading to enhanced CS in PC but with reduced porosity and permeability. These findings support the potential of RCA as a sustainable alternative to NCA in PC production.

Keywords: Pervious Concrete, Pretreatment, Natural Coarse Aggregate, Recycled Concrete Aggregate, Sustainable Construction

Influence of Governing Parameters on the Compressive Strength Development of Fly ash-based Geopolymer Mortar

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Abstract. The compressive strength of geopolymer concrete largely depends on the binder that holds the concrete in the matrix. This study investigated the salient parameters influencing the strength development of geopolymer mortar which comprises of fly ash, sodium silicate, sodium hydroxide and sand. The fly ash which was obtained locally from power corporation in Botswana was pre-treated and analyzed for physiochemical and mechanical properties. A total of thirty-six mixes were developed following the ratio of 1:2.75 of binder to sand with the following variables: alkaline activator to fly ash ratio, concentration of sodium hydroxide, ratio of sodium silicate to sodium hydroxide and type of activators. The mix was cast and thermally cured at a temperature of 70ºC for 24 hours and allowed to rest and cured at room temperature until the test dates. From the tests carried out, it was deduced that ratio of alkaline activator to fly ash, sodium silicate to sodium and type of activators are crucial to strength development with concentration of sodium hydroxide having minimal influence.

Keywords: Geopolymer Mortar, Alkaline Activator, Strength Development, Fly Ash, Botswana.

The Impact of Bacillus Cereus on Mechanical Properties of Cement Mortars in Sulphate Rich Environments

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Abstract

This study investigates the effect of *Bacillus Cereus*, a bacterium known for its biocalcification properties, on mechanical and durability properties of cement mortars exposed to sulphate environments. Sulphates, often present in groundwater or industrial waste, can significantly degrade concrete structures. Cement mortars were prepared using bacteria solutions of varying concentrations (10^{-5}, 10^{-7}, and 10^{-9} cells/ml). Ninety bio-mortar cubes (50 mm x 50 mm x 50 mm) and thirty conventional mortar cubes were cast. The conventional mortars were cured in potable water and sulphate solution, while bio-mortars were distributed across these curing conditions for periods of 7, 14, 28, 56, and 90 days. A sulphate solution was prepared by dissolving 1000 g of sodium sulphate (Na_2SO_4) in 20 liters of water, yielding a 5% solution (50 g/L). Additionally, cylindrical prisms (50 mm x 150 mm) coated with epoxy were partially exposed to sulphate ingress and sliced after 90 days to assess penetration depth and sulphate concentrations. Results after 90 days showed compressive strengths of bio-mortars cured in water as 25.9, 28.1, 27.2, and 25.7 MPa for 0, 10^{-5}, 10^{-7}, and 10^{-9} cells/ml, respectively. Mortars cured in sulphate showed corresponding strengths of 13.2, 17.7, 10.0, and 8.5 MPa. Sulphate ingress concentrations at a depth of 150 mm for the same samples with bio-mortars were 109.5, 4.4, 4.7, and 1.3 mg/L, demonstrating significant resistance to sulphate penetration. Mortars with 10^{-5} cells/ml exhibited superior mechanical and durability properties, confirming the effectiveness of microbial impregnation in enhancing performance.

Keywords: Bio-mortars, Bacillus Cereus, mechanical and durability properties, biocalcification properties, Sulphate solution.

Compressive Strength and Non-Destructive Evaluation of PLC Concrete with High-Volume Clay Pozzolana

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Abstract: Portland Limestone Cement (PLC) is gaining widespread use as an eco-friendly alternative to Ordinary Portland Cement (OPC), gradually replacing it in many countries. In Ghana, clay pozzolana has been used for over 40 years, but performance data primarily focuses on its use with OPC. This study investigates the effects of incorporating 20% and 50% clay pozzolana as a partial replacement for PLC in producing 30 MPa concrete. The concrete's behaviour was evaluated using compressive strength testing and non-destructive techniques, including pulse velocity and electrical surface resistivity. The results show that the 20% clay pozzolana mix achieved the target characteristic strength at 28 days, while the 50% replacement required extended curing (90 days) to reach the desired strength. The non-destructive tests (NDT) showed non-correlated results, suggesting distinct factors influencing the concrete's performance. The study recommends further research on the durability and environmental impact of using clay pozzolana with PLC to enhance sustainability in construction.

Keywords: Portland Limestone Cement, Clay Pozzolana, Compressive strength, Non-Destructive Testing (NDT), Sustainability

Activation Energies of Alkali-Silica Reactive Aggregates: A Review

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Abstract. Alkali-aggregate reaction (AAR) is a deterioration mechanism that occurs in concrete structures due to reactions between reactive aggregate components and alkali hydroxides in the concrete pore solution. In its form of alkali-silica reaction (ASR), siliceous aggregates are involved in the reactions, leading to the formation of an alkali-silica gel. When this gel is exposed to moisture, it expands, causing internal stresses within the concrete, resulting in crack formation and serviceability decline. Test methods for ASR include laboratory tests and field tests. These methods can be categorised as diagnostic and prognostic. Diagnostic tests determine and confirm the presence of ASR in concrete, while prognostic tests predict the extent of the reaction and long-term expansion. Prognostic tests, however, face challenges due to factors such as alkali leaching and poor correlation with in-situ conditions. Recent literature suggests that activation energy could be used as an indicator for assessing ASR reactivity in aggregates. Activation energy is a concept from Arrhenius' theory, representing the minimum energy required to initiate a chemical reaction. The dilatometer developed by the Texas Transport Institute (TTI) shows promise in measuring the activation energy. However, limited research has been conducted on the activation energies of aggregates, particularly in the South African context. This review forms part of an ongoing study at investigating activation energies of alkali-silica reactive aggregates. It aims to synthesise current literature and test methods currently in use, and explores the concept of activation energies in predicting ASR behaviour and the possibilities of using it in the South African context.

Keywords: Alkali Silica Reaction, Expansion, Activation Energies, Alkali Silica Gel, Siliceous Minerals.

Chemical Characterization of Pumice Material Sourced from Mbeya, Tanzania

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Abstract. Pumice, a lightweight volcanic material abundantly available in Mbeya, Tanzania, is underutilized and often discarded following excavation activities. In most construction projects within the region, conventional materials like clay soil, river sand, normal-weight aggregates, and cement are predominantly used, leaving the potential of pumice largely unexploited. This study presents a comprehensive chemical characterization of pumice sourced from two locations, MUST main campus (Sample A) and Wimba (Sample B), to assess its suitability as a supplementary cementitious material (SCM). Energy Dispersive X-ray Fluorescence (EDXRF) analysis revealed that Sample A contained 70.3% SiO_2, 17.9% Al_2O_3, and 3.53% Fe_2O_3, while Sample B had 71.3% SiO_2, 17.3% Al_2O_3, and 3.38% Fe_2O_3. The combined SiO_2, Al_2O_3, and Fe_2O_3 content for both samples exceeded the 70% ASTM C618 threshold for pozzolanic materials, confirming strong pozzolanic properties. Additionally, K_2O was 5.21% in Sample A and 5.05% in Sample B, while CaO was 0.667% and 0.763%, respectively.SO_3 was detected at 0.448% (Sample A) and 0.482% (Sample B), and TiO_2 at 0.528% and 0.507%, respectively. Na_2O and MgO were not detected. The high levels of SiO_2 and Al_2O_3 suggest strong pozzolanic properties, while the low CaO content indicates that pumice would function primarily as a pozzolanic additive rather than a primary binder. Consequently, these preliminary findings confirm that pumice is better suited as a supplementary cementitious material (SCM) and filler rather than a complete replacement for cement. By partially replacing cement with pumice, it could be possible to reduce the carbon footprint, contributing to more sustainable construction practices.

Keywords: Pumice, chemical characterization, pozzolanic properties, supplementary cementitious material, XRF Analysis

Flexural Behaviour of UHPC Beams with Externally prestressed FRP Bars

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Abstract. In the construction sector, external prestressing is commonly employed to manage the stresses and deflections in concrete structures. Nonetheless, the degradation of prestressed steel tendons has significantly restricted its practical use. FRP tendons have become a viable alternative due to their exceptional strength and resistance to corrosion. By utilizing UHPC and prestressed FRP, which are high-quality materials, it is possible to construct more durable structures with improved material efficiency. This project, therefore, evaluates the flexural behaviour and hence the capacity of Prestressed FRP-UHPC beams through both experimental and analytical methods. The experimental findings reveal that fully prestressed beams underwent brittle failure, with their shear capacity influenced mainly by the effective prestressing stress in FRP tendons and the ultimate tensile strength of UHPC. Conversely, partially prestressed members exhibited a more ductile failure mode. Based on the results, it is concluded that prestressed FRP tendons hold significant promise for application in construction projects.

Keywords: UHPC, external tendons, FRP, flexural capacity, prestressed bars.

Mechano-chemical activation of smectites as an alternative to thermal activation

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Abstract

The main technology used for the activation of raw clays for use as SCMs is thermal activation (calcination). However, recently it has been shown that mechano-chemical activation (MCA) can be used as an alternative. In addition, kaolins are the most widely used raw clays, but in some regions smectites are more widely available. This study focuses on the use of MCA for smectites and how that can improve performance of activated clay limestone cement (ACLC-50) compared to calcination. MCA was carried out for 2, 6 and 10 h using a traditional laboratory ball mill with a speed of 60 rpm. The activation effectiveness was assessed by XRD and TGA, and performance was assessed using the R3 standard and compressive strength. Results show that, while MCA does not lead to complete amorphization as calcination does, it induces structural disorder and preserves specific surface area (SSA). This results in fast early reactivity and better compressive strength up to 28 d. These outcomes highlight the potential of MCA in the practical application of smectite-based ACLC-50, as well as to enhance mechanical performance.

Keywords: Smectite, Mechano-chemical activation, Calcination, Reactivity, Compressive strength

Advancing Sustainable Waste Management through the Application of a Dynamic BIM-based Systems Integration in Construction

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Abstract. Several studies conducted indicate that huge quantities of waste and pollutants generated by building construction and demolition activities are directly linked to heart disease and other environmental risks. Despite its potential, there are numerous challenges to overcome when using Building Information Modeling (BIM) in the construction industry to manage waste sustainably and achieve net-zero. The potential of BIM to improve sustainability has been demonstrated by the numerous cities that have successfully incorporated it into their waste management systems. To promote sustainable waste management, this study investigates how BIM-aided systems might be incorporated into construction via a narrative appraisal. This study indicates the possibility of advancing sustainable waste management through the application of BIM-aided systems in construction has been investigated. Therefore, the application of BIM-based waste management to minimize waste is here to stay for a long time and will further advance in years to come. Future research could focus on developing BIM-based strategies tailored to the unique environmental and economic conditions of emerging countries. Furthermore, future studies could explore the integration of BIM with other technologies, such as IoT and AI, to optimize waste management processes.

Keywords: Building Information Modeling, Carbon Emission, Circular Values, Net-zero Construction, Sustainable Development.

Moving Concrete Innovation to Implementation: Lab2Slab2Practice

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Abstract. Implementation of new materials in construction requires sufficient assessment of engineering performance and mitigation of risks to public safety, cost-efficient use of limited infrastructure funding, and cost-efficient use of available research/development funds. New materials should undergo thorough evaluation to ensure they meet engineering performance requirements, truly reduce emissions, are constructable, have scalable supply chains to meet at least regional demands, and are cost-effective enough for large-scale implementation. A much faster pace of data-driven confidence-building is needed for procuring agencies, owners, and the materials and construction industries, to create a pipeline of new lower-carbon materials moving from conceptual ideas to standard practice. This paper outlines a step-wise standardized process for efficiently screening new materials while building and communicating confidence. Context is also presented for how strategically placed centers of excellence focused on transitioning materials from conception to implementation will expedite the implementation of low-carbon concrete through a process called Lab2Slab2Pilot2Practice. The process is designed to be repeatable globally, to develop locally available materials to build local economies and employment.

Keywords: Performance, scalability, cost-effectiveness, constructability.

Development of a Life Cycle Inventory Database for Environmental Impact Assessment of Construction Materials in Burkina Faso

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Abstract. The construction sector plays a key role in the growth of developing countries but faces major environmental challenges, such as greenhouse gas emissions and resource depletion. Life Cycle Assessment (LCA) is an essential tool for evaluating these impacts and promoting sustainable choices. However, its effective application is limited by the lack of local databases. This study introduces a systematic framework (LOCAL-LCID2) for creating local Life Cycle Inventory (LCI) databases for developing countries and demonstrates its application in Burkina Faso through a comparative LCA of commonly used materials, covering the cradle-to-gate stage. The methodology follows seven steps: (1) identification of materials, (2) data collection, (3) analysis of material and energy flows, (4) development of LCI database, (5) structuring the database using SimaPro 9.6.0, (6) calculation of environmental impacts via ReCiPe 2016 Midpoint, and (7) uncertainty analysis using the pedigree matrix and Monte Carlo simulation. Results reveal that concrete blocks have the highest Global Warming Potential (GWP), with 88.3% of CO2 emissions from cement, while traditional earth-based materials show significantly lower impacts. The study finds that importing clean energy could reduce the GWP sector by 26.9%, and transportation accounts for 4-40% of emissions for imported materials. This framework provides decision-makers with tools for implementing sustainable construction practices through strategic material selection and regional resource optimization.

Keywords: Life Cycle Inventory Database, Life Cycle Assessment, Construction Material, Burkina Faso, Environmental Impact.

The Liget Budapest Project - best practices of sustainable urban concepts

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Abstract. The Liget Budapest Project, Europe's largest cultural urban renewal initiative, exemplifies sustainable urban development by integrating advanced architectural design, ecological preservation, and modern infrastructure. Situated in Budapest's historic Városliget (City Park), this project revitalizes a cultural landmark while implementing green construction techniques, energy-efficient systems, and innovative transport solutions. Key sustainability features include eco-friendly building materials, renewable energy integration, and water recycling technologies. Iconic structures such as the New National Gallery and Museum of Ethnography adopt advanced insulation and energy systems, significantly reducing carbon emissions. Importantly, 60% of the project area is dedicated to revitalized green spaces, enhancing biodiversity, improving air quality, and supporting community well-being. The project employs participatory design, ensuring cultural heritage preservation aligns with contemporary needs. Its sustainable mobility plan incorporates pedestrian pathways, cycling routes, and enhanced public transport to minimize vehicle dependency. This holistic approach fosters ecological balance while enhancing urban quality of life. It offers replicable strategies for addressing rapid urbanization, emphasizing climate-responsive design, green infrastructure, and renewable energy can guide urban growth while mitigating environmental impacts. Community engagement and leveraging local resources ensure projects remain culturally relevant and economically viable. The case study demonstrates that sustainable urban renewal can harmonize cultural preservation, environmental resilience, and economic development. Its principles and methodologies provide a framework for emerging economies to create inclusive, resilient cities that address global climate challenges while fostering regional growth.

Keywords: Liget Budapest, cultural adventure parc, content-filled developments, strategic urban planning, inclusion

Innovating Across Continents Through Sustainable Design How studio OMT architect's Projects Bridge Cultural Heritage and Innovation

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Abstract: Africa's rapid population growth, with projections indicating that a third of the global population will reside here by 2050, places immense pressure on existing infrastructure. The increasing demand for new buildings necessitates faster, more resource-efficient, and innovative construction methods. Studio OMT Architects addresses this challenge by developing construction solutions that utilize innovative biobased timber applications and adapt to local contexts.

In East Africa, studio OMT architects have extensively explored timber use, adapting European and North American practices to suit local conditions. With an established mass timber sector in parts of the global north, the initial approaches in East Africa have been adapted from European techniques. However, the challenge lies in optimizing the use of locally available timber, which may not always meet the same building quality standards as compared to European timber. Studio OMT architects' solution involves combining European-engineered timber with local, low-tech options to create cost-effective designs. These innovations enable faster fabrication and reduce waste, ultimately lowering costs. Although importing engineered timber incurs higher initial costs, studio OMT architects aim to stimulate local manufacturing in the future. Lower labor costs in East Africa also help balancing these expenses. Beyond timber, studio OMT architects utilize various sustainable design strategies, such as energy-efficient systems, passive design techniques for optimal daylighting and ventilation, and the integration of renewable energy sources like solar power. These approaches minimize environmental impact and enhance occupant comfort. Our diverse team works relentlessly from our offices in Nairobi (Kenya), Poznan (Poland) and Berlin (Germany) to explore sustainable solutions in terms of design and material for our projects in both East Africa and Europe.

Keywords: Population Growth, Infrastructure Pressure, Biobased Timber, Sustainable Design, Local Adaptation, Innovative Construction.

The study the best practices of sustainable urban concepts for infrastructure and buildings: A case study of Tanzania.

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Abstract. This study examines the best practices of sustainable urban concepts for infrastructure and buildings in Tanzania, focusing on the challenges of rapid urbanization and environmental issues. Case studies from cities Dar es Salaam, Arusha, and Dodoma highlight effective strategies, including green building standards, urban planning policies, and community initiatives that promote renewable energy, waste management, and climate adaptation.

Key findings underscore the importance of local governance, stakeholder engagement, and public-private partnerships for implementing sustainable solutions. Critical sustainability factors were identified and ranked by their relative importance indices (RII): RII): Rapid urbanization (RII, 0.8), Climate and environmental factors (RII, 0.91), Waste Management (RII, 0.88), Socio-economic pressures (RII, 0.85), Lack of community engagement (RII, 0.89), Pollution (RII,0.85), Health and education pressures (RII,0.92) and Housing and infrastructure challenges (RII, 0.79)

The study emphasizes the need for awareness education, financial incentives, and regulations to foster sustainable practices, serving as an essential resource for policymakers and urban planners in Tanzania seeking to navigate the complexities of sustainable urban development.

Keywords: Sustainable urban development, Tanzania, infrastructure, case studies, best practices, urban resilience, rapid urbanization.

A Review on Barriers and Opportunities for Implementing Sustainable Building Practices in Sub-Saharan African Urban Areas: Future frameworks for sustainable Urban development

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Abstract. The rapid urbanization in Sub-Saharan Africa presents both challenges and opportunities for implementing sustainable building practices. This review article explores the barriers and opportunities associated with sustainable urban development in the region, focusing on successful examples and frameworks that can inform future initiatives. Key findings reveal that barriers such as economic constraints, technological limitations, and regulatory challenges hinder the adoption of sustainable practices. However, opportunities exist through community engagement, innovative financing mechanisms, and public-private partnerships. The methodology employed a systematic literature review, analyzing peer-reviewed articles, case studies, and reports to identify successful sustainable building practices and their implications. The results indicate that integrating local knowledge, enhancing capacity building, and fostering collaboration among stakeholders are essential for promoting sustainability. Future research directions include investigating the long-term performance of sustainable buildings, the role of technology in enhancing sustainability, and the effectiveness of policy frameworks. Addressing these areas will contribute to the development of resilient urban environments in Sub-Saharan Africa.

Keywords: Sustainable building practices, Sub-Saharan Africa, Urbanization, Community engagement

Mitigating Wildfire Risk and Reducing Carbon Emissions: Utilizing Biomass Waste as Biochar in Sustainable Construction Practices

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Abstract. Controlled fire has been successfully used in Africa to manage biomass waste for centuries; however, poor resource management can produce destructive wildfires, intensified by climate change. Wildfires (uncontrolled fires) release sequestered carbon from biomass all at once, significantly increasing particulate matter in the air and greenhouse gas emissions. This challenges the goal of achieving carbon neutrality by 2050.

As a part of good biomass waste management practice, biomass waste can be used to produce renewable energy and biochar as a co-product or biochar as the main product. Biochar, a carbon-rich solid, is produced by the thermochemical conversion of biomass in a limited oxygen (<5%) environment.

This study investigates the incorporation of high-carbon (>90%) biochar from urban wood waste, into concrete pavers by replacing 10% Portland limestone cement (PLC) by weight. The biochar used in this study was milled in a ceramic ball mill to achieve the desired fineness. In the laboratory, mortar cubes with pre-wetted biochar reached a statistically similar compressive strength to the control mix. However, mortar cubes with dry biochar showed significant strength reduction and a 124% higher rate of capillary water absorption than control. Next, during factory production, the dry-biochar incorporation led to practical challenges, resulting in a less uniform mixture compared to the control. The 28-day strength of pavers decreased by 13%, and the percent water absorption increased by 1.63% with 10% biochar replacement by weight of PLC. The key findings highlight the importance of mix conditions (in a small-scale controlled environment or a large-scale production facility) and biochar's moisture state during factory production to match laboratory performance.

Preliminary carbon calculations indicate a 52% reduction in CO_2 emissions for the biochar-modified pavers. As biochar production is projected to grow by 900% by the end of 2025, its use should expand into other cement markets, including ready-mix concrete which demands higher workability and strength. Further investigation is needed to explore the application of biochar as a carbon sequestration element in other cement uses, such as ready-mix concrete.

Keywords: Biochar, Biomass Waste Management, Carbon Emissions, Concrete Pavers, Portland Limestone Cement (PLC).

Addressing urban sustainability challenges through nature-based solutions: a case study of Mzuzu City in Malawi

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Abstract. Malawi is urbanising rapidly with increasing informality. One of the consequences of this is escalating environmental degradation, which is one of the drivers of climate change-induced disasters such as flooding. Urban flooding has increased in frequency and intensity over the past decade. Cyclone Freddy, which devastated communities in Blantyre city in March 2023, was a poignant reminder of the adverse impacts of environmental degradation and urban informality. These two phenomena are posing urban sustainability and resilience challenges for the country, with urban residents increasingly becoming vulnerable to climate change impacts. Conventional approaches to climate change action are failing to address the root causes of urban vulnerability to climate change impacts. Studies have demonstrated that nature-based solutions (NBS), natural interventions which restore, protect and manage degraded ecosystems, can enhance urban resilience and sustainability. Mzuzu city is Malawi's fastest growing city and has suffered the highest rates of environmental degradation over the past three decades, thus contributing to the city's increased vulnerability to climate change-related hazards such as flooding. This study maps land use and land cover changes (LULC) to detect and contextualise spatio-temporal changes which have catalyzed environmental degradation and exacerbated its impacts on the city's poor residents. By mapping LULC, this study explores the role of NBS in addressing the city's sustainability and resilience challenges. The study uses remote sensing data to map spatio-temporal changes in the city from 1986 to 2020. It concludes that NBS are critical to addressing the city's resilience and sustainability challenges.

Keywords: Environmental Degradation, Urban Encroachment, Urban Sustainability, Urban Resilience, Nature-based Solutions, Urban Green Infrastructure

Potentials for the African informal sector to become a driving force in sustainable construction

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Abstract: Concrete remains the most popular structural building material used globally. Yet the production of its binding agent, cement, accounts for approximately 5% of global energy consumption and 6-7% of embodied carbon emissions. Therefore, exploring solutions for sustainable building materials design and construction methods is necessary. Africa has abundant clay deposits that could be used as a sustainable construction material.

In Zambia, the informal sector builds most of the low-rise and low-cost infrastructure. The informal sector already unconsciously practices principles of circular economy and uses low-process construction materials. A survey conducted found that most Zambians building low-rise houses rely on the informal sector which offers flexibility in construction methods. This flexibility allows individuals to minimise project costs and avoid wastage. There is potential for integrating sustainable practices within the informal sector through community engagement, awareness, accessibility of low-carbon cement alternatives and fostering collaboration between the informal and formal construction sectors. This study highlights the importance of the informal sector's inherent strengths and addresses its limitations to achieve sustainable and inclusive housing development in Africa.

Keywords: Urbanisation; informal sector; circular economy; sustainable concrete construction.

Advancing Carbon Emission Mitigation in Modern Methods of Construction: A Framework for Sustainable Innovation

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Abstract: The construction industry significantly contributes to global carbon emissions due to its high energy consumption and substantial greenhouse gas output. Modern methods of construction (MMC) offer opportunities to reduce environmental impacts, yet a critical gap remains in translating innovative strategies into scalable, measurable, and context-specific outcomes. This study develops a framework to guide carbon emission mitigation within the MMC domain, incorporating insights from advanced technologies, lifecycle assessments, and policy mechanisms. Drawing from a comprehensive literature review, including case studies, the paper explores MMC techniques' carbon reduction potential, such as modular construction and 3D printing, across various stages of the building lifecycle. The study presents key insights into the synergies between design optimization, material efficiency, and renewable energy integration in construction processes. Additionally, it identifies the enablers and barriers to adopting MMC in both developed and developing contexts, providing pathways to scale innovative solutions globally. The findings offer actionable recommendations for industry stakeholders, policymakers, and researchers, contributing to advancing sustainable construction practices and global climate goals.

Keywords: Modern Methods of Construction, Life Cycle Assessment, Carbon Emissions

Quantifying the Current and Future Greenhouse Gas Emissions from Road Infrastructure in Africa

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Abstract

This paper uses a newly developed framework for quantifying current and future greenhouse gas (GHG) emissions from Africa's road transportation sector. It provides first-order estimates for road infrastructure projects (new road construction and existing road maintenance and rehabilitation) and vehicle-related emissions through 2050. Africa's current road network was estimated from available data, and its future growth (2021-2050) was modeled using three approaches. Road construction makes up the majority of GHG emissions from infrastructure built before 2021, with culverts and bridges contributing smaller but still significant amounts. By 2050, vehicle operation is projected to account for 85% of total transportation emissions, followed by vehicle manufacturing (7%), new road construction (4%), and road maintenance/rehabilitation and road roughness (approximately 2% each). While infrastructure-related emissions are relatively small compared to vehicle-related emissions, their impact remains significant. Reducing GHG emissions from Africa's road transportation infrastructure requires a comprehensive approach incorporating sustainable materials, efficient construction, and proactive maintenance. Low-carbon alternatives, renewable energy integration, and life cycle assessments in planning are key strategies.

Keywords: Life Cycle Assessment (LCA), road transportation, greenhouse gas (GHG) emissions, sustainable construction.

Embodied efficiency: Enabling low-carbon concrete housing in Nairobi, Kenya

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Abstract. Less Economically Developed Countries (LEDCs) are increasingly vulnerable to climate-related threats while struggling to meet the demand for urban construction and affordable housing. A major reason for this is the high cost of materials, which can comprise 60-80% of the total cost of residential construction, yet their construction resembles the inefficient practices of More Economically Developed Countries (MEDCs) that were developed to reduce labor over material costs. Typically, building structures are designed for the highest local stresses rather than an accurate distribution of their global stresses, resulting in oversized elements. However, research has shown that shape optimization can result in a 60% reduction in a structure's embodied carbon while using readily available and code-compliant materials. Unfortunately, designers do not typically have access to shape optimization methods that enable the design of fabricable low-carbon concrete structures. Addressing the gap between optimization research and engineering practice, this paper discusses an efficient slab design that demonstrates how shape optimization can reduce the material costs and embodied carbon of multi-story concrete housing while meeting local codes and constraints. The prototype is designed for construction by partners in Nairobi, Kenya, to meet structural codes while using substantially less material than standard practice.

Keywords: Affordable housing. Concrete construction. Shape optimization. Structural engineering.

The Role of Green Public Procurement in Driving Demand and Standardization of Low-Carbon Construction Materials

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Abstract

Steel and concrete remain two of the most carbon-intensive construction materials on the planet—together accounting for nearly 50% of industrial emissions. The stimulation of significant demand for low-carbon steel, cement, and concrete, particularly in the construction sector, is a critical enabler of industrial decarbonization. Demand signals such as public procurement commitments can help stimulate market demand for sustainable alternatives, encouraging industries to adopt clean technologies and scale up the production of low-emissions materials.

Approximately 20-30% of global construction industry revenues come from purchases made by the governments at various level. Green Public Procurement (GPP) involves the process by which public authorities seek to procure goods, services, and works with a reduced environmental impact throughout their life cycle. Aggregated demand signals for decarbonized industrial products are essential to drive the transition towards a low-carbon economy.

This paper examines the impact of GPP in driving demand for low-carbon materials and fostering standardization, drawing insights from key initiatives.

Durability of Concrete with Agro-based Ashes

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Abstract. This study investigates the potential of using agro-based ashes—specifically rice husk ash (RHA) and sugarcane bagasse ash (SCBA)—as sustainable partial replacements for cement in concrete. The objective is to evaluate their impact on concrete durability properties, with an emphasis on resistance to environmental degradation factors. Concrete samples were prepared with varying dosages of RHA and SCBA as partial cement replacements. Durability assessments included tests for water permeability and sulfate resistance to gauge performance under conditions that typically contribute to material degradation. In addition, mechanical properties such as compressive and flexural strength were examined to ensure structural integrity. The results indicate that incorporating agro-based ashes enhances sulfate resistance due to a refined pore structure, which reduces permeability and improves durability. As the dosage of these ashes increases, the concrete's resistance to environmental impact also increases. Durability was assessed by tracking compressive strength retention, visual inspection for surface degradation and depth of water penetration. Strength tests revealed an increase in compressive and flexural strength values at replacement levels of up to 20% for RHA and 15% for SCBA, with volumetric replacements compared against a control mix for accuracy. In conclusion, this study demonstrates that agro-based ashes such as RHA and SCBA can significantly enhance the durability of concrete against external factors, providing an eco-friendly, sustainable alternative in concrete production and offering both environmental and practical benefits for construction applications.

Keywords: Agro-based ashes, Rice husk ash (RHA), Sugarcane bagasse ash (SCBA), Concrete durability, Cement replacement, Sulfate resistance, Water permeability, Eco-friendly concrete

Influence of climate-controlled and elevated temperature curing on the strength and macropore of metakaolin-slag-based geopolymer mortar

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Abstract: This research investigated the influence of climate-controlled (CC) and elevated temperature (ET) curing conditions on the strength performance and macropores of MK-slag-based geopolymer mortar (GM). Four mixes were developed by replacing MK with slag up to 15% at 5% intervals. The GM was excited using Na_2SiO_3 and NaOH at an aggregate-to-binder ratio of 1.6, and an alkaline activator-to-binder ratio of 0.73. Slump, slump flow, and the initial and final setting times were characterised. Cubes and beams specimens were cured at an ET of 80 ℃ for 24h before curing in a CC room (23±2 °C and 65±5 % relative humidity), and other samples were cured in a CC room only. Specimens were examined for compressive, flexural, and direct tensile strengths after 7- and 28-day curing ages. Macro-pores were investigated by conducting an X-ray computed tomography (X-CT) scan on the samples after 28 days. The workability of GM in a fresh state decreases as slag content increases and becomes stiff at 15% slag inclusion. The strength properties of the ET-cured specimens outperformed the CC-cured in all the mixes developed. X-CT shows a reduction in macropores with increasing slag inclusion in the CC-cured specimens. However, ET curing further reduced macropores and consequently increased the strength of specimens. Conclusively, slag inclusion and ET curing reduce macropores and improve the strength of GM.

Keywords: Geopolymer mortar, metakaolin, slag, curing, strength properties, X-CT

Modern Earth Based Construction Approaches for Sustainable Construction

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Abstract: This article proposes an exploration of earth bricks, a traditional material in Egypt and the Middle East, as a contemporary building material through a blend of local craftsmanship, engineering, and advanced technology. While often viewed as a low-tech option in under-resourced communities, this project aims to reposition earth bricks within a modern architectural and structural context. By integrating tools like the AR-HoloLens, the project will support collaborative building experiences and engage stakeholders in hands-on earth brick construction, fostering a shared understanding of sustainable practices.

In Luxor, near Hassan Fathy's historic architecture, students and local partners will participate in constructing a mock-up wall using digitally guided assembly in January 2025, with structural design rules informed by engineering perspectives. This process, facilitated by parametric design software, will provide real-time structural guidance to the builders, ensuring accuracy while celebrating manual craftsmanship. The collaboration between the German University in Cairo (GUC) and OST seeks to develop and test bricks that will support a free-form wall, engineered to stabilize itself through its form. The real-time digital model will be streamed to the HoloLens, guiding the precise placement of each brick in this mixed-reality environment.

Ultimately, the project aims to prioritize human engagement over automation within digital assembly processes, supporting local identity with a traditional, sustainable material and reimagining earth bricks as a meaningful alternative to CO_2-intensive materials in modern architecture. It also analyses materials and potential structural design in modern settings and for future housing, comparing different approaches of Middle East, East Africa and Europe.

Comparative case study analysis for sustainable urbanization of Sub-Saharan African Cities

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Abstract: African cities have been experiencing severe urbanization. However, for a resilient and sustainable city growth, urban planning strategies must meet the inherited city structures and people's needs. Cities in Africa are already facing multiple challenges stemming from unplanned urban growth including formation of slums and informal settlements, unreliable social infrastructures as well as insufficient public transportation and, thus, significant mobility challenges.

One reason is the complexity of understanding sustainable urbanization between an ecological, economic and social balance, identifying the most striking challenges and the interdependency between historical city growth, social drives and contemporary needs, and the most powerful tools for sustainable growth.

In our study, we investigated six cities in six different countries of Sub-Sahara Africa on their current urbanization status, planned urbanization strategies and prospective challenges and potentials. Kumasi (Ghana), Douala (Cameroon), Johannesburg (South Africa), Ibadan (Nigeria), Gondar (Ethiopia) and Dar es Salaam (Tanzania) were showcased regarding their urbanization history considering pre-colonial, colonial and post-colonial periods, their most striking contemporary challenges and analyzed in terms of urban planning strategies. By comparing their very specific and very different urbanization challenges, we identified their unifying elements. Besides political commitment and funding strategies, *backcasting* approaches can be helpful for each case study to understand successful and adoptable urbanization strategies. For each case, implementation of strategies targeted more social inclusion, sustainable engineering and mobility, would ensure continuous resilient city growth. The results will enable further research towards sustainable city growth for cities across Sub-Sahara Africa.

Decarbonising Construction: Timber in East Africa Housing

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Abstarct: Africa's population is rising. The urban population is projected to grow by 1 billion by 2050. More people, more homes, more buildings, especially apartment buildings as cities densify and peri-urban areas become urban. More buildings, more carbon-intensive materials if we continue with 'business as usual'.

Can timber be a safe and cost-effective lower carbon material? Can it be mainstreamed in the housing construction across the continent? Won't that deplete our forest cover? Will it be accepted as a high-quality building material?

Since 2022 Arup, CSFEP, Gatsby Africa, and other partners have been working together to explore these questions and discover whether timber is a viable, sustainable material that can be used at scale for housing construction in East Africa.

We have worked with the forestry sector in Uganda, Tanzania, and Kenya to understand the size of the potential sustainable forest supply into the construction sector. We have worked with manufacturers to understand the costs associated with growing capacity for timber processing. We have worked with project developers and designers to understand the appetite for timber in housing construction. We have understood how it can be incorporated in the regulatory environment.

We have concluded that timber can be used at scale and can save a significant proportion of carbon emissions in the process. A roadmap to adoption at scale is presented in this paper.

We ask both 'can we afford to change? and 'can we afford not to?'.