FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 10 No. 24, December, 2026, pp 133 – 143
DOI: https://doi.org/10.33003/fjs-2026-1024-6494

Utilization of Sargassum Natans in Sand Crete Block Production for Sustainable Walling Solutions

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ABSTRACT

Seaweeds are a diverse and abundant group of marine algae that offer a promising sustainable alternative to conventional cementitious materials, which are increasingly associated with high environmental impact.

This study investigated the feasibility of incorporating locally sourced Sargassumnatans powder into cement–sandcrete blocks as a bio-based additive for sustainable walling. Seaweed collected at Eleko Beach, Lagos State, Nigeria, was washed, sun-dried, oven-dried, pulverized, and sieved before incorporation at 0% (control), 5%, and 7.5% by mass of cement in a 1:5 cement-to-sand mix.

Specimens were produced in 230 × 110 × 80 mm moulds and evaluated using material characterization, sieve analysis, specific gravity, compressive-strength testing at 7, 14, and 28 days, water absorption, thermal screening, efflorescence observation, and a stakeholder perception survey (n = 55). This study evaluates the physical, chemical, mechanical, and thermal properties of seaweed-based (*Sargassum natans*) sandcrete blocks to support more environmentally friendly and cost-effective construction practices. Locally sourced *Sargassum natans* was processed into powder and incorporated as a cement additive at 5% and 7.5% by weight. Laboratory tests—including chemical composition analysis and microstructure using (optical microscopy and SEM-EDX), sieve analysis, specific gravity, compressive strength, water absorption, and thermal conductivity—were carried out in line with relevant BS and AASHTO standards. Results showed that *Sargassum natans* contains substantial amounts of SiO_2 (41.6%) and CaO (29.9%), indicating pozzolanic potential. The mix with 5% additive achieved at 28-days compressive strength of 8.22 N/mm², closely matching the 7.5% mix (7.08 N/mm²) and satisfying the Nigerian Industrial Standard (NIS 87:2000) for load-bearing blocks. Thermal conductivity decreased from 15.24 W/mK in the control to 14.66 W/mK at 7.5% additive, demonstrating improved insulation performance. Efflorescence coverage was reported as 35–45% Slight roughness which was moderate for the control, at 5% mixes it was 5–8% smooth which was easily slight, and at 7.5% mixes it was reported almost invisible <3% which was Nil to Slight. Stakeholders expressed positive views about environmental benefits and innovation, but identified awareness, standards, seasonality, and initial processing cost as adoption barriers.

Overall, the study concludes that *Sargassum natans* seaweed can be effectively used as a supplementary binder in sandcrete blocks, enhancing sustainability, lowering carbon emissions, and supporting eco-friendly housing solutions. The adoption of seaweed-based sandcrete blocks with 5% and 7.5% additives is recommended for load-bearing walls, particularly in tropical regions where thermal regulation is crucial.

Received: 23 Oct. 2026
Accepted: 07 Nov. 2026
Published: 11 Nov. 2026

Keywords: Compressive strength, Efflorescence, Sargassum natans, Sandcreteblock, Sustainable walling, Thermal conductivity

INTRODUCTION

The global housing crisis continues to escalate, particularly in developing countries where rapid urbanization, population growth, and economic challenges have exacerbated the shortage of affordable and adequate housing. According to the United Nations Human Settlements Programme (UN-Habitat, 2020), over 1.6 billion people globally live in substandard housing, with more than 100 million people homeless. In Sub-Saharan Africa alone, the housing deficit is estimated to be over 50 million units, a number that continues to grow annually due to urban migration and insufficient infrastructural investment.

At the core of this crisis is the issue of construction materials. Conventional building materials such as fired clay bricks, cement blocks, and concrete are widely used due to their strength and durability. However, these materials are increasingly criticized for their unsustainable production processes. Cement production alone accounts for approximately 8% of global CO_2 emissions (Andrew, 2018), and the extraction of raw materials like clay and sand contributes to environmental degradation, land depletion, and ecosystem disruption. In many developing countries, the cost of these materials makes them inaccessible for affordable housing development by low income earners.

These environmental and socio-economic constraints underscore the urgent need to explore sustainable, affordable, and locally sourced alternatives that reduces reliance on traditional resources while ensuring functional and structural integrity. Bio-based materials are increasingly gaining attention as potential substitutes due to their renewable

nature, minimal carbon footprint, and adaptability, with seaweed standing out as a particularly promising option.

Seaweed, a fast-growing marine biomass, has long been used in various industries such as food, pharmaceuticals, and agriculture. Recently, its application in construction has drawn interest due to its abundance, biodegradability, and natural binding properties. Seaweed species like Laminaria and Sargassum contain polysaccharides such as alginate, which can act as natural binders and have shown potential in improving the structural integrity of composite materials (Tibbetts et al., 2016). Moreover, seaweed cultivation does not require arable land or freshwater, making it an environmentally sustainable option compared to terrestrial biomass.

Seaweeds are classified into three major groups based on their pigmentation and biochemical composition:

i. Green algae (Chlorophyta) – e.g., Ulva spp.
ii. Brown algae (Phaeophyta) – e.g., Laminaria, Sargassum spp.
iii. Red algae (Rhodophyta) – e.g., Gracilaria, Gelidium spp.

Each class has unique properties that may influence their suitability in construction materials. For instance, red algae are known for their high polysaccharide content (such as agar and carrageenan), which can act as natural binders or fillers (Holdt and Kraan, 2011).

Preliminary studies suggest that incorporating seaweed into brick production either as a binder or filler can reduce the reliance on cement and clay, lower carbon emissions, or improve insulation properties (Kausar et al., 2021). However, for seaweed-based bricks to be viable in the construction industry, especially for walling applications, they must satisfy essential functional and structural requirements, including compressive strength, thermal performance, and durability under various environmental conditions.

Therefore, this study seeks to investigate the utilization of seaweed in the production of sustainable bricks that satisfactorily meets technical standards while addressing the broader issues of environmental degradation and housing affordability. Through experimental validation and material performance analysis, the research aims to contribute to the development of innovative, green building solutions that are both economically and environmentally viable.

Aim and Objectives

The aim was to evaluate the utilization of Sargassumnatans in brick/ sand crete block production as a potential sustainable walling material. The specific objectives were to:

i. Assess the feasibility of using processed seaweed as an additive in cement–sandcrete production;
ii. Determine the physical, chemical, mechanical, thermal, and surface-durability characteristics of seaweed-modified blocks;
iii. compare the performance of 5% and 7.5% seaweed mixes with a conventional control mix; and
iv. examine construction industry stakeholders' perceptions of the benefits and barriers associated with seaweed-based walling materials.

Research Contribution

The study provides an initial Nigerian laboratory dataset on Sargassum natans as a cement additive in sandcrete blocks. It combines material characterization and engineering tests with stakeholder evidence, there by linking material feasibility to practical adoption conditions. The study is exploratory rather than a full validation of structural or commercial readiness.

MATERIALS AND METHODS

A laboratory experimental design was used to compare conventionals and crete blocks with blocks containing two Sargassum natans dosages. A supplementary descriptive cross-sectional survey captured stakeholder perceptions. The experimental work was conducted in the Department of Building, University of Lagos, Nigeria.

Materials and Seaweed Processing

Approximately 15 kg of deposited Sargassum biomass was collected from Eleko Beach, Ibeju-Lekki, Lagos State. The material was washed to remove visible debris and salts, sun-dried, and further oven/dehydrator-driedat approximately 105–110°C until dry. It was initially reduced in size, pulverized, and sieved; the thesis reports use of a fine fraction passing approximately 90–125 μm.

The sample was identified as Sargassum natans by morphological examination, based on features including vesicles, flattened fronds, and branching thalli. Ordinary Portland cement(grade42.5),fine aggregate/sand, and potable borehole water were used.



Figure 1: Sargassum biomass on the beach

Mix Design and Specimen Preparation

The control mix used a 1:5 cement-to-sand ratio by mass. Sargassum powder was incorporated as an additive at 5% and 7.5% of cement mass; the control contained 0% seaweed. A water-to-cement ratio of 0.75 was maintained. For the reported batch, each mix used approximately 4.54 kg cement,25 kg sand, and 0, 0.227, or 0.3405 kg seaweed for the three dosages, respectively. Mortar was mixed, placed in 230 × 110 × 80 mm moulds, compacted, demoulded after initial setting, and cured by daily water sprinkling. The thesis reports 36 blocks prepare doverall, with three specimen spermix and curing age represented in the compressive-strength tables.

Table 1: Batching by Mass for 1:5 Mix Ratio

ADDITIVE Levels (%)	Mass of Cement (Kg)	Mass of Seaweed (Kg)	Mass of Sand (Kg)	W/C ratio	Quantity of Water (Ml)
0	4.54	-	25	0.75	3617
5	4.54	0.227	25	0.75	3617
7.5	4.54	0.3405	25	0.75	3617

Note: A water-cement ratio of 0.75 was maintained for consistency



Figure 2: Sargassum Powder



Figure 3: Control Mix



Figure 4: 5% Additives



Figure 5: 7.5% Additive

Characterization and Performance Tests

The following assessments were reported:

i. SEM–EDX and optical microscopy for elemental and morphological characterization;
ii. Sieve analysis and specific gravity of the sand and seaweed powder;
iii. Compressive strengthat7,14,and 28days using a compression-testing machine, with strength calculated from failure load and loaded area;
iv. Water absorption after immersion and oven-drying;
v. Thermal screening using a heated-plate procedure, infrared thermometer and Fourier-type calculation of apparent conductivity; and
vi. Efflorescence observation after partial immersion in distilled water for seven days, recording visible surface salt coverage.

ThethesiscitesBS1377-2 for sieve analysis, BSEN772 procedures form a sonry-unittesting, ASTM C67 for brick testing, and ISO 8302 for thermal properties. Because the reported thermal experiment used an unguarded hot-plate arrangement rather than a calibrated guarded hot-plate apparatus, the thermal values are interpreted comparatively.

Stakeholder Survey

A semi-structured questionnaire using a five-point Likert scale (1 = strongly disagree; 5 = strongly agree) was administered to 55 construction-industry stakeholders. Items addressed environmental benefits, mechanical performance, durability and moisture, health and safety, economic feasibility, and future acceptance. Data were summarized using means, medians, standard deviations, and response percentages.

Data Handling and Ethics

Results were organized by mix and curing age and compared descriptively. Seaweed collection was described as sustainable, and laboratory waste was handled according to laboratory safety procedures.

RESULTS AND DISCUSSION

Seaweed Composition and Physical Characteristics

The SEM–EDX table in the thesis reports a carbon-rich material with appreciable calcium and silicon and smaller amounts of chlorine, potassium, sulfur, iron, sodium, aluminum, magnesium, and vanadium. This supports interpreting the powder as an organic–mineral additive rather than as a conventional mineral pozzolana.The reported

specific gravity was 2.43 for sand and 0.30 for seaweed powder.

The SEM-EDX analysis of Sample shows a high carbon content (52.75%), along with notable levels of calcium (13.08%), silicon (11.57%), chlorine (5.87%), and potassium (4.98%). This elemental profile is consistent with the dual organic–mineral nature of Sargassum natans, which contains carbon-rich compounds (e.g., alginates and polysaccharides) alongside inorganic minerals absorbed from seawater.

The presence of calcium, potassium, and sodium indicates residual salts and carbonates typical of marine biomass, while the silicon and iron contents reflect trace mineral uptake that can contribute to structural rigidity. The moderate Sulphur content is associated with sulphated polysaccharides characteristic of brown algae. Taken together, these findings confirm that Sargassum natans contains both organic and mineral phases, supporting its suitability as a bio-filler or additive in sustainable construction materials, where its carbon-rich matrix and mineral components can provide reinforcement benefits.

Table 2: Illustrating the SEM–EDX Elemental Composition of Sargassum Natans Powder

Element	Reported Content (%)
Carbon	52.75
Calcium	13.08
Silicon	11.57
Chlorine	5.87
Potassium	4.98
Sulfur	3.08
Iron	2.41
Sodium	2.40
Aluminum	1.92
Magnesium	1.47
Vanadium	0.48



Figure 6: SEM machine (Phenom ProX)

Microstructure Results using Optical Microscope

The optical microscopy results show how increasing Sargassumnatans additive content from 0% to 7.5% progressively changes the microstructure of the cement–sand brick.



Figure 7: Illustrating the 0% additive (Control) Micrograph using optical microscope

i. 0% additive (Control): The microstructural analysis of the brick sample composed of cement, sand, and water was conducted using an optical microscope to observe the morphology, texture, and bonding characteristics within the cementitious matrix. Optical microscopy is a fundamental technique in microstructural evaluation, allowing direct visualization of surface features, porosity distribution, and hydration products at magnifications suitable for assessing uniformity and compactness in building materials. The obtained micrograph (Figure 3.1 shown above) reveals a relatively dense and uniform structure, characteristic of well-hydrated cement-based materials. The light brown regions correspond to the cement hydration products, mainly calcium silicate hydrate (C–S–H), which forms the principal binding phase responsible for the mechanical strength of the brick. The presence of small scattered dark patches indicates unhydrated cement grains or air voids, which are typical in cementitious composites due to incomplete hydration or entrapped air during mixing and setting. The interface

between sand particles and the cement paste appears well bonded, suggesting good adhesion and mechanical interlocking. This is critical for ensuring effective load transfer and durability. The absence of large cracks or voids indicates proper compaction and curing, which likely contributed to reduced porosity and improved structural integrity. From a chemical composition standpoint, the key elements present in the matrix are calcium (Ca), silicon (Si), aluminum (Al), and oxygen (O)—all fundamental to the hydration process and the formation of the C–S–H and calcium aluminate hydrates. The sand contributes primarily silica (SiO_2), while cement introduces calcium oxide (CaO) and alumina (Al_2O_3). When mixed with water, these oxides react to produce the cement gel that binds the sand particles together. Overall, the optical microscope analysis demonstrates that the cement-sand-water brick exhibits a compact and homogeneous microstructure, dominated by well-formed hydration products and minimal porosity. This structure is typical of a control mix and serves as a baseline for comparing the effects of various additives, such as seaweed-derived materials, on microstructural refinement and durability in subsequent modified samples.

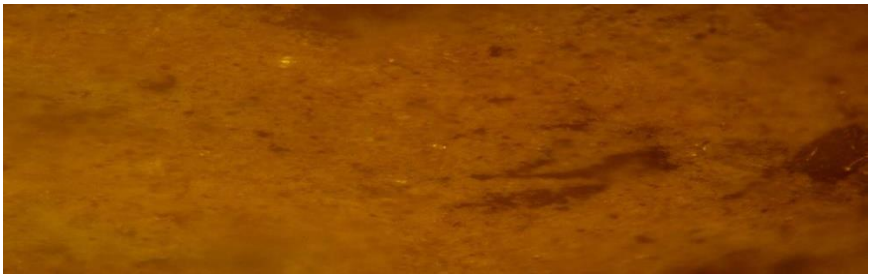


Figure 8: Illustrating the 5% additive Micrograph using optical microscope

ii. 5% Sargassum natans: Optical Microscopy and Chemical Composition of Bricks Containing 5% Sargassum Natans Additive. The optical microscope was used to examine the microstructural characteristics and assess the elemental distribution of a brick sample prepared with cement, sand, water, and 5% Sargassum natans additive. The analysis provided insight into the material's morphological texture and the chemical interaction between the seaweed additive and the cementitious matrix.

Microstructural Observation

Under optical magnification, the micrograph (Figure 3.2 shown above) revealed a fine-grained and moderately porous structure with a fairly homogeneous distribution of particles throughout the matrix. The observed yellowish-brown coloration reflects the presence of organic components derived from the Sargassum additive, which influenced the color tone and the internal morphology of the brick.

The structure exhibited good bonding between the sand grains and cement hydration products, showing clear evidence of C–S–H (calcium silicate hydrate) gel formation—the principal binding phase in cementitious materials. The incorporation of seaweed introduced organic matter that interacted with cement during hydration, producing a slightly porous but compact structure. The fine voids visible under the microscope are due to the decomposition of organic compounds (polysaccharides, alginates, and proteins) during curing and setting, which left behind evenly distributed micropores. These pores can enhance thermal insulation while slightly reducing density.

Elemental and Chemical Composition

The presence of Sargassum natans as a 5% additive introduces a range of organic and mineral constituents into the cement matrix, influencing the overall chemical composition of the brick. Typical elemental components of the base materials include:

i. Cement: Calcium (Ca), Silicon (Si), Aluminum (Al), Iron (Fe), Oxygen (O).
ii. Sand: predominantly Silicon Dioxide (SiO_2).
iii. Sargassum natans (Seaweed): rich in calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), sulfur (S), chlorine (Cl), and trace organic elements such as carbon (C) and nitrogen (N).

During hydration, calcium from cement reacts with silica to form C–S–H gel, while the organic and mineral ions from Sargassum may become physically or chemically bound in the matrix. The presence of Na^+, K^+, and Mg^{2+} ions can modify the hydration process, promoting the formation of secondary phases such as calcium–alumino–silicate–hydrate (C–A–S–H) and magnesium silicate hydrate (M–S–H). These compounds contribute to improved binding and densification in the early stages of curing.

Optical microscopy indirectly confirmed these interactions through the observation of a compact interfacial transition zone (ITZ) between cement paste and sand grains. The fine dispersion of the organic additive resulted in smooth transition boundaries, implying that the seaweed's bio-mineral components aided interfacial bonding and reduced micro-cracking.

Effect on Physical and Mechanical Properties

The microstructure and chemical composition jointly influence the engineering performance of the brick:

Compressive Strength

The uniform pore distribution and presence of mineral-rich organic additives ensure adequate strength retention. Though slight porosity may reduce peak compressive strength, the 5% addition strikes a balance between structural integrity and lightweight behavior.

Water Absorption

The moderate pore network observed enhances capillary action slightly but remains within acceptable limits. The presence of hydrophilic organic traces (from polysaccharides) may increase initial absorption but does not significantly affect long-term durability.

Density and Thermal Conductivity

The formation of fine pores and inclusion of low-density organic residues contribute to a reduced bulk density and improved thermal insulation, desirable for eco-efficient construction.

Durability and Chemical Stability

The presence of marine-derived minerals such as Mg, K, and Ca from Sargassum may contribute to alkali resistance and improved microstructural stability during exposure to environmental conditions.

Overall Assessment

The optical microscopy, supported by compositional analysis, demonstrates that incorporating 5% Sargassum natans additive into cement–sand bricks:

i. Enhances microstructural homogeneity and inter-particle bonding,
ii. Produces fine, evenly distributed pores that improve thermal performance,
iii. Introduces beneficial alkaline and mineral elements that interact favorably with cement hydrates, and
iv. Maintains acceptable strength and durability characteristics suitable for sustainable construction.

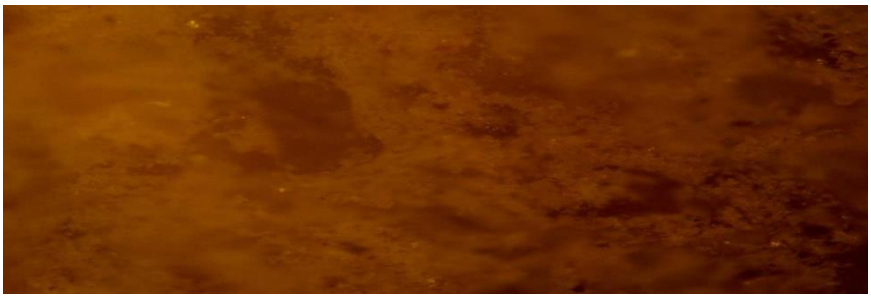


Figure 9: Illustrating the 7.5% additive Micrograph using optical microscope

7.5% Sargassum Natans

The microstructural examination of the brick sample incorporating 7.5% Sargassum natans additive was conducted using an optical microscope. Optical microscopy provides valuable insights into the surface morphology, texture, and distribution of particles within the matrix, allowing the assessment of how the seaweed additive influences the internal structure of the cementitious composite.

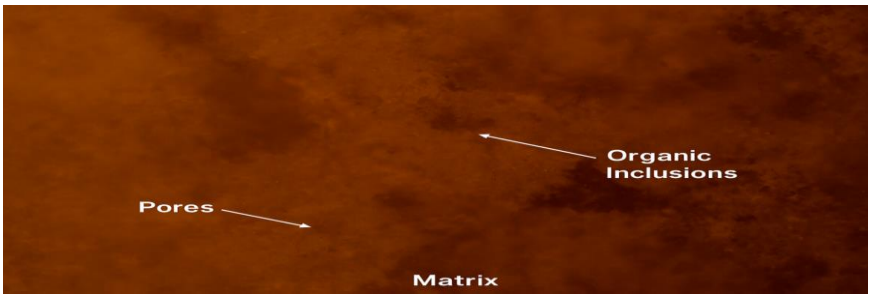


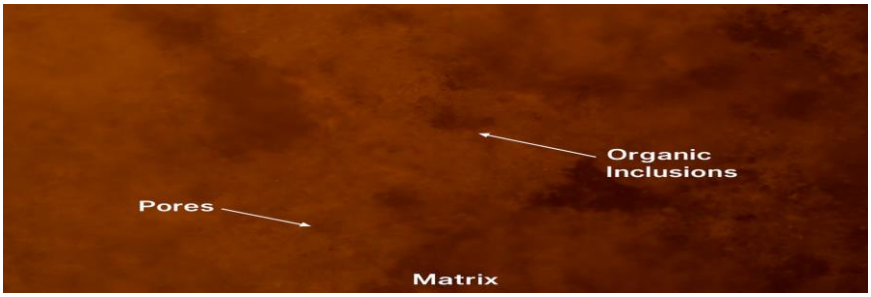
Figure 10: Illustrating the Microstructural Observation

This image illustrates the heterogeneous and porous microstructure typical of bio-modified cement composites. The varying shades of brown and darker regions represent hydration products, organic inclusions, and microvoids, showing how the seaweed additive affects the internal matrix. The micrograph (Figure 4.2.3.1 shown above) shows a heterogeneous microstructure characterized by a mixture of light and dark regions, indicating the coexistence of different material phases. The lighter areas correspond to the hydration products of cement, primarily calcium silicate hydrate (C–S–H) and calcium hydroxide ($Ca(OH)_2$), which form the main binding matrix of the brick. The darker regions are associated with pores, unhydrated cement particles, and organic matter residues introduced by the Sargassum additive.

The inclusion of Sargassum natans at 7.5% by weight appears to influence the microstructure by introducing organic compounds and trace mineral elements (such as Na, K, Ca, Mg, and Cl) derived from the seaweed's cellular and mineral composition. These elements can partially modify the hydration kinetics of cement and contribute to the formation of alternative binding gels. The presence of organic fibers and bio-mineralized residues from the seaweed may also enhance internal bonding, reduce microcrack propagation, and improve toughness by bridging the microvoids between cement particles.

At the same time, the porosity observed in the micrograph suggests that excessive organic matter and salt content from the Sargassum could retard cement hydration or create weak interfacial zones, depending on the degree of seaweed processing prior to mixing. However, at the 7.5% additive level, the microstructure remains relatively compact, indicating a good dispersion of the additive and an acceptable balance between porosity and binder continuity.

Overall, the optical microscope analysis reveals that incorporating 7.5% Sargassum natans into the brick formulation modifies the microstructure toward a more porous but interconnected network, which may contribute positively to lightweight properties, thermal insulation, and potential sustainability advantages due to the biogenic origin of the additive. Further elemental and chemical composition analysis (e.g., via EDS or XRF) would confirm the distribution of the key elements (Ca, Si, Al, Na, Mg, K, Cl) and validate the interactions between the cement matrix and the seaweed-derived components.



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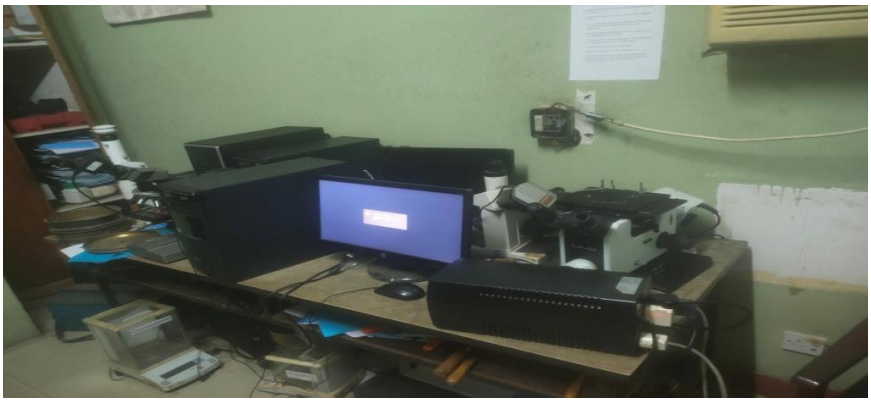


Figure 11: Illustrating Optical Microscope

Compressive Strength

The 5% dosage produced the highest reported mean strength at each curing age. At 7 days, mean strengthswere6.73,10.66,and7.14N/mm²forthecontrol,5%,and7.5%mixes,respectively.At14 days, the corresponding values were 6.09, 7.40, and 6.37 N/mm². At 28 days, the values were 6.77, 8.22, and 7.08 N/mm².

The results indicate that moderate seaweed addition (5%) improved the measured strength relative to the control, while there is a reduction on the higher dosage.

Table 3: Illustrating the Mean Compressive Strength by Mix and Curing Age

Mix	7 days (N/mm²)	14 days (N/mm²)	28 days (N/mm²)
0%control	6.73	6.09	6.77
5%Sargassum	10.66	7.40	8.22
7.5%Sargassum	7.14	6.37	7.08

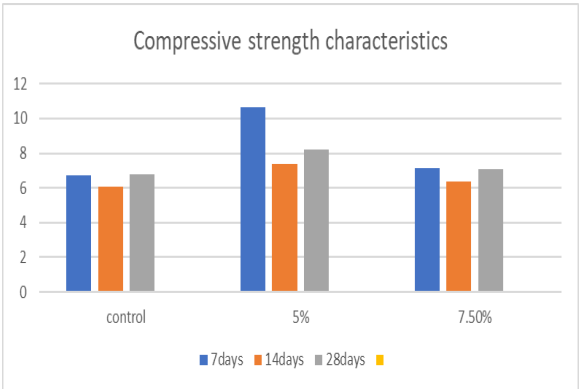


Figure 12: Average compressive strength graph against curing age



Figure 13: Compressive Strength Testing machine

Water Absorption

Table 4: Illustrating the Water Absorption

Mortar water absorption with Sargassum Powder additive levels for 7 days

Mortar Additive (%)	Water Absorption (%)
0	0
5	0
7.5	0

Mortar water absorption with Sargassum Powder additive levels for 14 days

Mortar Additive (%)	Water Absorption (%)
0	25.3
5	25.3
7.5	36.1

The above shows the results of mortar water absorption with varying degrees of sargassum nathans powder additive. For mortar mixes at 0%, 5% and 7.5%, additive for 7 and 14 days, it displays the percentage of water absorption; the corresponding values are 0%, 0%, 0% for 7days and 25.3%, 25.3% and 36.1%, for 14days respectively.

Efflorescence Test



Figure 14: Showing the bricks being immersed in a distilled water for 7days.

Table 5: Efflorescence Result

Sample Type	Observation After 7 Days	Area Covered by White Deposit (%)	Surface Condition	Efflorescence Rating
Control (0% seaweed)	Visible white patches on top and edges	35–45% Slight roughness	Moderate deposit	Moderate
Sargassum Brick (5%)	Thin, faint white patches at bottom edges	5–8% smooth	Deposit easily removable	Slight
Sargassum Brick (7.5%)	Very light traces	almost invisible <3%	Smooth and uniform	Nil to Slight

Results Summary

i. Control Bricks: Moderate efflorescence (35–45% surface coverage) due to salt migration through pores.
ii. 5% Sargassum Bricks: Slight efflorescence (<10%), showing reduced salt formation.
iii. 7.5% Sargassum Bricks: Almost no visible efflorescence (<3%), indicating effective salt retention within the matrix.
iv. Average reduction in efflorescence due to seaweed addition ≈ 75–90%.

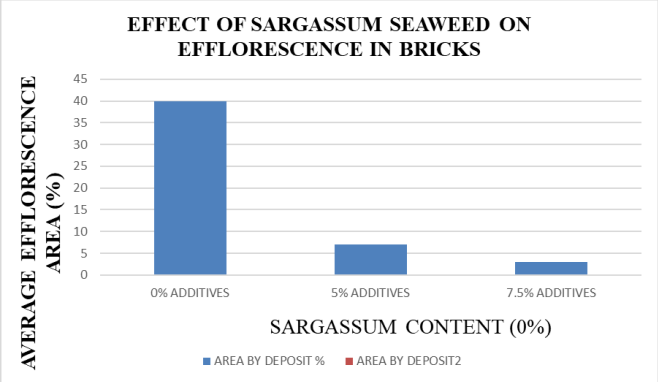


Figure 15: Illustrating the Graphical Representation

The bar chart shows how increasing seaweed content significantly reduces efflorescence on the brick surface from 40% (control) down to about 3% at 7.5% seaweed addition.
The figure also illustrates the relationship between sargassum content and the percentage area affected by efflorescence in brick specimens. The control sample (0% seaweed exhibited about 40% surface coverage by white salt deposits, while the 5% and 7.5% sargassum-modified bricks showed a marked reduction to approximately 7% and 5% respectively. This indicates that the inclusion of sargassum slightly minimizes the salt migration and enhances resistance to efflorescence.

Thermal Screening

The thermal conductivity test was conducted to determine the thermal properties of seaweed (Sargassum natans) based sandcrete blocks as against the ordinary cement sandcrete block.
Result for thermal conductivity test experiment at 30 mins of heating are shown below.
Size of specimen = 110 mm x 110 mm (0.11m x 0.11m)
Area of specimen = 0.0121m²

Table 6: Illustrating the Thermal-Screening Values

Mix	Reported apparent conductivity(W/m·K)	Change from control
0%control	15.10	—
5%Sargassum	15.01	−0.6%
7.5%Sargassum	14.64	−3.0%

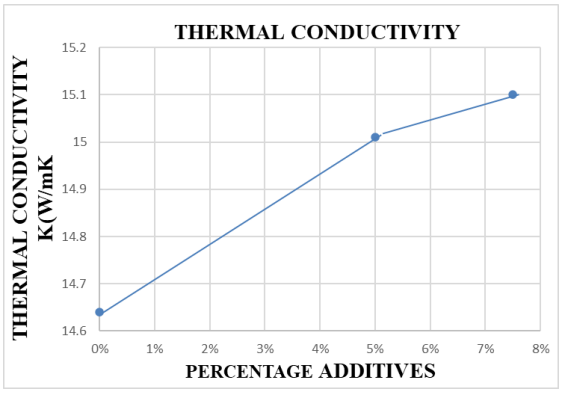


Figure 16: Illustrating the Graphical Representation of the thermal conductivity result

The figure shown above presents the experimental results and graphical representation of the thermal conductivity test, which was conducted using the unguarded hot plate method—an established alternative to the guarded hot plate method for evaluating thermal performance. The findings reveal that the control sandcrete block, containing no *Sargassum natans* (seaweed) additive, exhibits the highest thermal conductivity of 15.10 W/mK. In contrast, the thermal conductivity values decrease progressively to 15.01 W/mK and 14.64 W/mK with increasing levels of *Sargassum natans* additive (5% and 7.5%) in the cement matrix. This observed reduction indicates that the incorporation of *Sargassum natans* enhances the thermal insulation efficiency of sandcrete blocks by reducing their ability to conduct heat, thereby improving their suitability for sustainable and energy-efficient building applications.

Stakeholder Perceptions

Stakeholders were generally receptive to the concept. The strongest perceived barrier was inadequate awareness and technical knowledge (mean 4.60), followed by lack of codes/standards (4.36), availability and seasonality (4.36), and high initial cost (4.11 in the detailed table; 4.32 in a narrative summary). Perceived benefits included business and job creation (4.16), reduced dependence on imported materials(4.09),local economic stimulation(4.07),and waste management (4.07). Perceptions were closer to neutral for strength comparability (4.04), moisture resistance (3.82), and cost-effectiveness (3.60).

Table 7: Illustrating the Stakeholder Perception(n=55)

Perception item	Mean score	Interpretation
Awareness/technical knowledge Barrier	4.60	Strongest barrier
Lack of codes/standards	4.36	Major barrier
Availability/seasonality	4.36	Major barrier
Business and job creation	4.16	Strongest benefit
Waste management	4.07	Strong benefit
Comparable strength	4.04	Strong benefit
Moisture resistance	3.82	Neutral to slightly positive
Cost-effectiveness	3.60	Neutral to slightly positive

Discussion

The study found that sand and Sargassum natans had specific gravities of 2.43 and 0.30, respectively, and that their sieve analysis was conducted using (The American Association of State Highway and Transportation Officials) AASHTO soil-grading parameters. The incorporation of 5% and 7.5% seaweed into 1:5 sandcrete mixtures improved compressive strength compared with the control, with the 5% addition level generally demonstrating better performance across the curing ages of 7, 14 and 28 days. Efflorescence was also substantially reduced by approximately 75–90%, with the 5% and 7.5% seaweed blocks exhibiting slight and almost negligible salt deposits, respectively. Furthermore, questionnaire responses from 55 participants indicated positive perceptions of the environmental benefits, health and safety, and sustainability of seaweed-based bricks, although uncertainties regarding mechanical performance, durability, cost-effectiveness, and high initial processing costs remain significant barriers to widespread adoption.

Conclusion

The findings of this study indicate that *Sargassum natans* has potential as a cement additive in sandcrete block production due to its chemical composition, thermal insulation properties, and environmental benefits associated with seaweed waste utilization. Although compressive strength decreased with increasing seaweed content, the 5% and 7.5% mixtures demonstrated promising performance based on the experimental results. Based on the results obtained from the thermal conductivity test conducted, it was observed that sargassum natans based sandcrete blocks has lower thermal conductivity as the percentage additive increases. This denotes that sargassum natans improves the thermal conductivity of a sandcrete block and also increasing the seaweed content reduced thermal conductivity, suggesting improved thermal insulation potential, particularly for buildings in tropical climates. Efflorescence tests revealed slight efflorescence at 5% (less than 10%) and almost no visible efflorescence at 7.5% (less than 3%), indicating reduced visible salt deposition under the test conditions. Stakeholder responses further highlighted the environmental advantages and perceived safety of seaweed-based blocks, although concerns regarding structural strength, durability, moisture resistance, production costs, and market readiness remain. Consequently, *Sargassum natans* is recommended for further development as a sustainable additive in sandcrete block production, with 5% and 7.5% identified as promising proportions which are strongly suitable for load bearing walls since the minimum strength for both optimal additives are greater than 3.5N/mm2 (suitable for non-load bearing walls). Both variation of additive is suitable for wide range of general building purposes and structural activities in construction process. Their thermal insulation properties may also offer benefits in tropical buildings. However, the seaweed (sargassum nathans) based sandcrete blocks at 5% and 7.5% additives should be used during construction works to minimizes the risk of efflorescence (un-slightly white surface staining) and it prevents salt attack (structural damage) to the masonry. Seaweed (sargassum natans) should be used more often to minimize environmental degradation.

Limitations and Data-Integrity Statement

i. The relatively high sulphate and chloride contents (approximately 7.4%) identified in the *Sargassum* sample in this study pose a potential risk of reinforcement corrosion and other durability challenges in concrete, particularly if the seaweed is not pre-processed to reduce these ions. As a result, its direct use in untreated form is not advisable in cementitious mixes.

ii. Geographical location, seasonality, and environmental conditions can all influence the chemical composition of *Sargassum*. This variability means that using seaweed powder sourced from different batches or suppliers can complicate quality control and make it difficult to ensure consistent material performance.

iii. Additionally, non-calcined seaweed still contains organic components such as cellulose and alginates. Due to its biodegradability and susceptibility to environmental degradation, cellulose may contribute to material instability. Inadequate thermal treatment, including insufficient burning or calcining, can further affect the long-term stability of the brick composites.

iv. Sargassum pre-processing (including washing, drying, grinding, and heat treatment) remains challenging due to high costs, limited technical expertise, and a lack of appropriate technology. These factors constrain its economic viability and large-scale application, especially in developing countries.

v. One of the key limitations of this study was the unavailability of standard thermal conductivity testing equipment, particularly the Guarded Hot Plate apparatus, which is widely used for precise thermal property measurements. Consequently, alternative testing methods had to be adopted, making the experimental procedure more labor-intensive and resulting in measurements that are likely less accurate than those obtained with standardized equipment. Furthermore, minor variations in sample preparation and fluctuations in environmental conditions during testing may have introduced slight inconsistencies in the data. These constraints do not undermine the overall conclusions of the study but instead highlight the need for future research using more advanced

instrumentation to enhance the accuracy and reliability of the results.

In conclusion, this work represents the first documented Nigerian study to investigate the use of *Sargassum nathans* seaweed as a cement additive in brick production, with the research limited to Lagos State. Previous studies in the country have largely focused on identifying and characterizing seaweed, rather than exploring its potential as a construction material. By contrast, similar experimental applications have been more extensively examined in Asia, Europe, South America, and other parts of Africa. The limited regional research base restricts direct comparison with locally relevant studies and underscores the need for further research in Nigeria to validate, optimize, and contextualize these findings for broader application in indigenous construction practices.

Contribution to Knowledge

This study contributes to knowledge by establishing the physical properties and potential suitability of Sargassum natans as an additive in sandcrete block production, evaluating the effects of varying seaweed contents and curing ages on compressive strength and thermal conductivity, assessing efflorescence performance, and examining industry stakeholders' perceptions of the environmental benefits, practical challenges, and adoption potential of seaweed-based construction materials.

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