Mixed Rice Husk Ash, Mahogany Fruit Ash, and Foaming Agent as Additives in Floating Concrete Blocks for Wall Panels

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Abstract*: This study investigates the use of agricultural waste materials—rice husk ash (RHA), mahogany fruit ash (MFA), and a foaming agent—as an additive in the production of floating concrete blocks for wall panels. The research aims to address environmental concerns by repurposing agricultural byproducts while developing eco-friendly construction materials. Four mix designs were formulated with varying cement replacement levels with RHA (10%, 15%, 20%) and MFA (5%, 10%, 15%), and tested for compressive strength, water absorption, density, and void ratio over 7-, 14-, and 28-days curing periods. Results revealed that Mixture 1 (10% RHA, 5% MFA) achieved the highest compressive strength of 2.8 MPa at 28 days, demonstrating optimal balance between sustainability and structural performance. Higher ash replacements (Mixtures 2 and 3) significantly reduced strength (0.3–0.4 MPa) and increased water absorption (up to 25%), indicating higher porosity. Density decreased with greater ash content, with Mixture 3 recording the lowest density (694.52 kg/m³), confirming lightweight properties. Cost analysis highlighted the economic viability of the proposed blocks, showing a 68% cost reduction compared to autoclaved aerated concrete. The study concludes that RHA and MFA can effectively replace cement up to 10% and 5%, respectively, to produce durable, lightweight floating concrete blocks. Higher replacements compromise structural integrity but remain viable for non-load-bearing applications. This research contributes to sustainable construction practices by valorizing agricultural waste, reducing deforestation, and offering a cost-effective alternative for lightweight wall systems in disaster-prone areas. Further studies on thermal and acoustic properties are recommended to broaden applicability.

***Keywords*: floating concrete, rice husk ash, mahogany fruit ash, foaming agent, lightweight blocks.**

1. Introduction

Most buildings now have wood walls; regular bricks are often used, despite their relative weight. Wall is one of the structural elements of a building and is typically composed of bricks, concrete blocks, concrete panels, wood boards, plywood, and gypsum. The use of brick, concrete blocks, and concrete walls will result in a large self-weight of the wall, which will increase the dead weight of the building. It is more desirable to use lighter materials to lessen the possibility of damage from earthquakes [1]. The floating blocks are made of environmentally friendly materials including rice husk and mahogany fruit. This product is manufactured and used without emitting harmful pollution into the environment. This is also an alternative for plywood dividers, contributing to reduced deforestation. The most common agricultural wastes in the Philippines were rice husk, rice straw, coconut husk, coconut shell, and bagasse [2]. The Philippines has a strong potential for biomass power plants since rice comprises one-third of the agricultural area, resulting in considerable volumes of rice straw and hulls [2]. Traditional floating concrete blocks, tough as they are, are weighed down by their heavy concrete hearts [3] This sinking feeling has researchers exploring lighter alternatives.

Rice husk (RH) is the outer cover of the rice grain which is removed during the milling process [4]. Rice husk is prevalent in the province of Aurora, in which rice fields are abundant, and some farmers burn it, potentially endangering the ozone layer. Rice husk is used as a fertilizer in various applications. After harvesting the rice crop, the rice husk can be found by the roadside in every rice field. Rice husk disposal is an increasing problem since rice husks leak greenhouse gases into the air as they decay [5]. Rice husk ash (RHA) contains high pozzolanic material that reacts with cementitious to enhance the strength and durability of foamed concrete. It is the byproduct of the rice milling process and is often considered a waste material. The addition of rice husk ash can reduce the weight of the blocks, making them more suitable for use in floating structures. The mahogany fruit holds potential in various fields. Like the wood itself, mahogany fruit ash is known for its hard and woody nature. This makes it a potential fuel source for charcoal production. Studies have shown its composition includes magnesium oxide, sodium oxide, and various other elements. This composition gives it pozzolanic properties, meaning it can react with calcium hydroxide to form cementitious compounds.

Mahogany plantations can have negative environmental consequences, such as deforestation and soil degradation. Mahogany trees can be susceptible to various pests and diseases, impacting their fruit production and overall health. Certain mahogany species can become invasive in non-native habitats, disrupting ecosystems and causing economic damage. That is why the researchers decided to make use of this agricultural waste to produce construction materials such as floating concrete blocks for wall panels. Foaming agents are used to create air bubbles in concrete, which reduces its density and weight. That is why it is an ideal additive for floating concrete blocks, as it can significantly reduce the weight of the blocks without compromising their strength. Additionally, foaming agents can also improve the thermal and acoustic properties of concrete, making it a more comfortable and energy-efficient option for floating structures.

Sand dredging destroys ecosystems, and [6] industrial waste clogs our planet. The researchers aimed to study recycled industrial waste for construction. This innovative approach not only reduces sand consumption but also gives industrial waste a responsible second life [7]. This research delves into developing floating concrete blocks using mixed additives like rice husk ash, mahogany fruit ash, and foaming agents, paving the way for a more environmentally friendly future. By burning agricultural waste, we can generate a fine powder material that can be used to make floating concrete blocks, as investigated in this study. This study looks at the impact of employing these additives on the physical and mechanical properties of blocks. The development of more ecologically friendly construction materials is becoming increasingly significant, and this study contributes to the investigation of alternative additives based on agricultural and organic waste.

This research focuses on the production of floating concrete blocks made from agricultural waste materials and additives such as mahogany ash, rice husk ash, and foaming agents. The production of blocks is meant to be used as wall panels, especially in particular areas where the weight of traditional building materials, such as bricks and concrete blocks, could be dangerous, like areas that are prone to earthquakes. The expected result of this research is to create lightweight concrete blocks using agricultural waste that have enough durability and strength to be used in building construction, especially in wall panels.

A. *Statement of the Problem*

This study investigates the development of floating concrete for wall panels using rice husk ash (RHA), mahogany fruit ash (MFA), and foaming agents as supplementary cementitious materials. The research addresses the following specific objectives:

1. To evaluate the effects of RHA, MFA, and foaming agents on the physical and mechanical properties of floating concrete blocks for wall panels, specifically:
   - *Physical properties*: texture, color, hardness, size/shape, mass, volume, weight, density, void ratio
   - *Durability characteristics*: water absorption
   - *Mechanical performance*: compressive strength
2. To determine the influence of RHA and MFA incorporation on the workability and consistency of floating concrete mixtures
3. To identify optimal proportions of RHA, MFA, and foaming agent for achieving target strength and density parameters in floating concrete blocks
4. To assess the economic viability of floating concrete blocks for wall panel applications through cost analysis of:
   - Material costs
   - Production costs

The findings from this investigation aim to contribute to the development of sustainable, lightweight concrete solutions for construction applications while promoting the beneficial reuse of agricultural waste products.

B. *Scope and Limitation*

This study investigates rice husk ash (RHA), mahogany fruit ash (MFA), and foaming agents as additives in floating concrete for wall panels. Materials sourced from Baler and Dipaculao, Aurora underwent characterization for chemical composition and particle size distribution. The research evaluated various foaming agents and optimized mix proportions to balance strength, buoyancy, and sustainability. Laboratory testing assessed compressive strength, density, water absorption, void ratio, and buoyancy performance following standardized procedures.

Limitations include potential variability in agricultural waste materials due to differences in biomass source, combustion conditions, and processing techniques, which may affect consistency and scalability of the developed concrete technology.

C. *Framework of the Study*

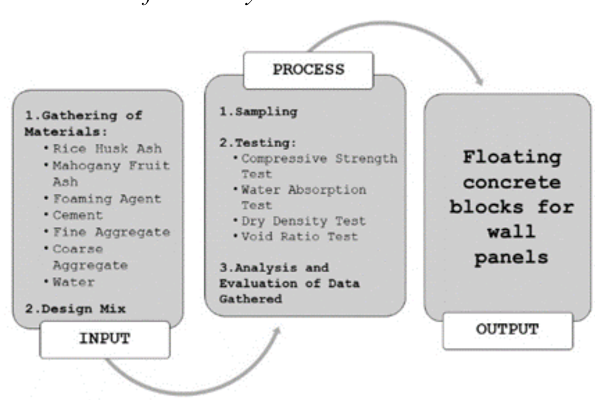

Fig. 1. Conceptual Framework of the Study

Figure 1 illustrates the process of producing floating concrete blocks for wall panels using mixed rice husk ash, mahogany fruit ash, and foaming agents. The process includes input, where relevant data is gathered, followed by experimentation involving material mixing, casting, and curing. The final stage involves testing the mechanical properties of the blocks. Ultimately, the study aims to design a floating concrete block suitable for wall panel applications.

2. Review of Related Literature

This chapter provides a detailed overview of literature on floating concrete, with a focus on the utilization of rice husk ash, mahogany fruit ash, and foaming agents as additives. Concrete is one of the most extensively utilized construction materials in the world due to its availability and low cost. However, typical concrete is prone to water damage and has limited waterproofing properties. As rising water levels from climate change continue to have an influence on our environment, there is growing interest in developing floating concrete as an alternative building material that can resist water exposure without structural degradation.

Floating concrete is defined as a mixture having a density lower than water, making it ideal for building floating structures while limiting land use (Datta, 2020). This new material achieves buoyancy by including lightweight aggregates or air-entraining agents. The present research project investigates the potential of agricultural waste materials, especially rice husk ash (RHA) and mahogany fruit ash, when mixed with foaming agents as additives to floating concrete blocks used for wall panels.

A. Properties And Advantages of Floating Concrete

Floating concrete has various characteristics that set it apart from ordinary concrete. Floating concrete has a lower density of 650-1850 kg/m³ compared to traditional concrete, which normally has a density of 2400-2500 kg/m³ [8]. This lower density contributes to its lightweight nature, making it easier to handle and install, lowering labor needs and associated expenses.

Aside from its low weight, floating concrete has good thermal insulation capabilities, which improves building energy efficiency [9]. Its cellular form provides effective soundproofing, making it ideal for applications needing sound management, such as conference rooms, studios, and auditoriums [10]. The material's decreased density also helps to improve seismic resilience when compared to ordinary concrete.

Water absorption is a significant property of floating concrete. When immersed in water, the enclosed cellular structure traps air and provides buoyancy [11]. Furthermore, floating concrete has greater durability and weather resistance, notably against freeze-thaw cycles and chemical degradation [12].

The economic benefits of floating concrete are significant. Its reduced weight lowers transportation and handling expenses while needing less raw material for manufacture. The resulting structures have better thermal insulation, lowering heating and cooling costs. Installation expenses are lowered as a result of easier handling and lower labor needs.

Furthermore, using agricultural waste products as additives helps to promote environmental sustainability by recycling items that would otherwise be thrown.

1) Properties of Rice Husk

Rice husk ash (RHA) is a promising pozzolanic substance having characteristics similar to silica fume or micro silica. RHA, which is formed during the rice milling process when husks are removed and burned, contains a high concentration of amorphous silica, making it an effective cement alternative. The use of RHA in concrete manufacturing yields high-quality concrete with reduced porosity and enhanced resistance to sulfate attack and chloride penetration.

Rice husks are composed of 20% ash, 22% lignin, 38% cellulose, and 18% pentose. When combusted, about 25% is converted into rice husk ash. RHA has a high silica concentration (87-97%), with trace levels of K_2O, CaO, MgO, Fe_2O_3, and Al_2O_3 (Rozainee et al., 2013).

Rice husk, as a lightweight material, has been utilized efficiently as thermal insulation in cement-based materials. Its inclusion into concrete enables the development of lighter-weight products with improved thermal qualities while reducing cement and aggregate quantities [13].

2) Properties of Mahogany Fruit

Mahogany trees, which belong to the Meliaceae family, grow quickly and are widely utilized for furniture and construction materials. Mahogany fruits are cylindrical, barrel-shaped, and grayish brown, measuring 2-6 cm long and 1-2 cm in diameter. The fruit has five strong outer valves and five smaller inner valves, which separate when mature to reveal densely packed seeds.

Mahogany fruit ash includes high levels of magnesia, which helps to strengthen concrete. Prior to the widespread usage of Portland cement, magnesium-based cement was common in building, with magnesia and sodium oxide playing important roles[14]. According to studies, mahogany fruit ash meets ASTM C618 criteria due to its pozzolanic components, making it a suitable alternative binding material.

3) Properties of Foaming Agent

Foaming agents are essential in developing the cellular structure required for floating concrete. These compounds encourage foam formation by dispersing gas bubbles in liquids or solids. Sodium Lauryl Ether Sulfate (SLES), a synthetic compound with the formula $CH_3(CH_2)_{11}SO_4Na$, is a frequent foaming ingredient in floating concrete manufacture. SLES is a cheap and effective surfactant that provides the essential air pockets in the concrete mix.

Foaming agents have pH levels ranging from 7 to 10, a specific gravity of roughly 1.02, and the ability to produce stable foam with a density of 50 to 80 g/l. These properties enable the development of enclosed cells or voids inside the concrete, trapping air and producing buoyancy.

B. Feasibility and Workability of Floating Concrete Blocks for Wall Panels

The use of rice husk ash, mahogany fruit ash, and foaming agents as additives to floating concrete offers a viable method to wall panel development. Researchers hope to achieve the best balance of weight reduction and strength maintenance by optimizing particle size and proportions in these materials.

Workability tests show that using rice husk ash as an additional binding material influence both workability and compressive strength characteristics [15]. While workability is deemed low when the slump falls below 50mm, this is acceptable for bulk concrete applications. Medium workability, obtained through suitable mixture design, works well for lightly reinforced concrete portions with minimal vibration or heavily reinforced sections with vibration.

The mixture improves concrete by lowering mass density while retaining sufficient strength. Furthermore, using agricultural waste materials as additives helps to reduce the negative environmental impacts connected with waste disposal.

C. *Environmental Impact of Utilizing Natural Resources*

The cement industry has a considerable environmental impact, using a lot of energy, depleting natural resources, and producing greenhouse gases, especially CO_2. The environmental impact of cement can be decreased by replacing it with rice husk ash and mahogany fruit ash.

Using these agricultural byproducts diverts items from waste streams, which aids in waste reduction efforts. Furthermore, because floating concrete has a lower density, it requires less material in total, resulting in less resource usage.

Structures built with floating concrete are more durable than traditional concrete, potentially prolonging service life and minimizing the need for replacements. Because water covers the majority of the earth's surface, the creation of floating structures minimizes the need for land for construction, providing an environmentally beneficial alternative to wood and metals in some applications [16].

D. *Research Gap*

There are a lot of research gaps that can be found in this study as it has no researchers have been trying to use mixed rice husk ash, mahogany fruit ash, and foaming agent as an additive to floating concrete for wall panels.

Rice husk ash is commonly found as an additive for aggregates but not for floating concrete. There is a lot of knowledge to know about the variety of additives that can be utilized to create floating concrete because this type of concrete is rarely used in the Philippines. There is still a lack of understanding of how natural resources can work as a construction material to be used as additives for concretes. Testing of materials is needed to know if the natural resources to be used are useful and functional when forming a specific construction material. To fully utilize the mixed rice husk ash, mahogany fruit ash, and foaming agents as an additive to floating concrete blocks for wall panels, the research gaps stated must be filled to prove its efficiency or not.

Table 1
Research gaps

NO.	RESEARCH GAPS	CITATION
1	Further investigation on the impact of w/c ratio change on the RHA-replaced concrete mix is recommended	(Al-Alwan et al., 2022)
2	The quantity of RHA added should depend on the expected workability but never exceed 10% by weight of the cement.	(Adinna et al., 2019)
3	Use of mahogany carpel ash to concrete mix and cement replacement for 5%, 10%, 15% and 20%.	(Cabahug et al., 2017)
4	Replacement of cement binder with pozzolanic rice husk ash for use in building materials.	(Henry & Lynam, 2020)
5	Further study on carbonation and drying shrinkage, thermal conductivity and sound insulation properties.	(Ghadge & Kamble, n.d.)

One of the critical research gaps is to know if the admixture was suitable to have further knowledge of how it can improve its workability and the compressive strength of the floating concrete in the natural environment., thermal conductivity, and sound insulation properties. Table 6 shows the data where a different research article was used in conducting their study. There is also a limited design approach and procedures being followed in each research study that is being reviewed.

The literature review signifies that the use of foaming agents, rice husk ash, and mahogany fruit ash as additives in floating concrete for wall panels is a promising development in building materials. This method has several advantages, including as lighter weight, better thermal and acoustic qualities, environmental sustainability through waste reduction, and cost savings on labor and materials.

These additions improve floating concrete's qualities, making it appropriate for a range of uses, especially in flood-prone locations or places with limited land. Long-term performance, carbonation, drying shrinkage, thermal conductivity, and sound insulation are among the other attributes that require further investigation to optimize mixture proportions. In response to environmental challenges like resource scarcity and climate change, floating concrete with rice husk ash, mahogany fruit ash, and foaming agents can be fully utilized by responding to the identified research gaps. This will help to create more resilient and sustainable construction methods.

3. Methodology

This study employed a quantitative experimental approach to develop and evaluate innovative floating concrete blocks incorporating rice husk ash (RHA), mahogany fruit ash (MFA), and foaming agents. The research methodology was structured to systematically investigate the physical and mechanical properties of these composite materials for potential application in wall panel construction.

The experimental design involves systematic testing to determine the optimal mix proportions and evaluate the resulting material properties, particularly compressive strength and buoyancy characteristics. Statistical analysis of the collected data will ensure unbiased and reliable results, enabling the development of floating concrete blocks suitable for wall panel applications.

The experimental process followed a sequential protocol:

For Mixed Additives

Step 1: Collecting and Material Characterization

A. *Rice Husk Ash (RHA):*

- *Incineration*: Rice husks are burnt by placing an ember in the middle and rice husk in the side and gradually mixing to transform them into rice husk ash while minimizing unburnt carbon.
- *Sieving and Grading*: Separate ashes by particle size for uniform concrete mixes. Use #200 sieve.

Fig. 2. Incineration of RHA

Fig. 3. Sieving and grading of RHA

B. *Mahogany (Swietenia macrophylla) Fruit Ash (MFA):*

- *Incineration*: Mahogany fruits are burnt in a controlled environment at temperatures between 500-700°C to transform them into mahogany fruit ash.

Fig. 4. Incineration of MFA

- *Sieving and Grading*: Separate ashes by particle size for lightweight properties. Use #200 sieve.

Fig. 5. Sieving and grading of MFA

C. *Foaming Agent:*

- *Select compatible agent*: Choose a commercially available agent suitable for concrete and desired bubble size control.
- *Density & Bubble Size Testing*: Conduct trial mixes with varying agent concentrations to achieve target density and air void distribution.

Fig. 6. Selecting of compatible foaming agent

Step 2: Preliminary Mix Design

A. *Proportioning:*

- *Cement*: Define base Portland cement content based on desired strength and constructability.
- *RHA & MFA Replacement*: Experiment with different replacement levels of cement with RHA (e.g., 10%-20%) and MFA (e.g., 5%-15%) for pozzolanic and lightweight effects.

- *Foaming Agent Dosage*: Optimize foaming agent concentration based on density & bubble size testing results.

B. Mix Preparation & Casting:

- *Batching*: Measure and mix all ingredients accurately using appropriate equipment.
- *Mixing*: Employ proper mixing techniques to ensure homogeneity and avoid air entrainment beyond controlled foaming.
- *Casting*: Cast small concrete samples in molds for testing (e.g., cubes for compressive strength, prisms for density, and water absorption).

Step 3: Testing & Optimization

C. Fresh Properties:

- *Workability*: Assess slump test results for ease of placement and finishing.
- *Setting Time*: Monitor initial and final setting times to confirm constructability.

D. Mechanical & Physical Properties:

- *Compressive Strength*: Test cured samples (e.g., 28 days) to ensure adequate load-bearing capacity.
- *Density & Buoyancy*: Measure block density and test if it floats in the water at the desired depth.
- *Water Absorption & Porosity*: Analyze water uptake of samples to assess potential water damage resistance.

E. Data Analysis & Iteration:

- Analyze all test results and compare them against set performance targets.
- Modify mix design parameters (e.g., RHA/MFA replacement, foaming agent dosage) based on findings.
- Repeat steps 2.2 and 3.2 until the desired properties are achieved.

F. For Floating Concrete Block

- *Step 1*: Mixing of mixed ashes, foaming agent, and cement
- *Step 2*: Pour the concrete mixture into a concrete mold.
- *Step 3*: Create three samples.
- *Step 4*: Curing
- *Sample 1*: 7 days
- *Sample 2*: 14 days
- *Sample 3*: 28 days
- *Step 5*: After curing days, conduct a compressive strength test.

G. Material Requirements

The following is the tabulated list of materials necessary in producing floating concrete blocks.

Table 2
Material specifications

MATERIALS	CLASSIFICATION	DESCRIPTION	SPECIFICATION
CEMENT	Portland Pozzolanic Cement (PPC)	-Normal: primarily used in construction in the Philippines -Portland-Pozzolan Cement	ASTM C595 Compressive Strength 7day: 2090 psi (14.41MPa) 14days: 2550 psi (17.59MPa) 28 days:3000 psi (20.70 MPa)
WATER		Clean and free from impurities that could affect concrete properties	The water needs to be pure to prevent side reactions from occurring, which may weaken the concrete or otherwise interfere with the hydration process.
RICE HUSK ASH	Supplementary Cementitious Material	Finely ground to pass through a 75mm sieve	ASTM C618 Fineness. Amount retained when wet-sieved on 45mm (No.325) sieve, max% 34.0
MAHOGANY FRUIT ASH	Supplementary Cementitious Material	Finely ground to pass through a 150mm sieve	ASTM C618 Fineness. Amount retained when wet-sieved on 45mm (No.325) sieve, max% 34.0
FOAMING AGENT	Concentrated Detergent Solution	Should remain stable and evenly distributed.	ASTM C1017

H. Mix Design

To acquire the desired strength, durability, and consistency and achieve the acceptable workability of the floating concrete. The researcher uses a different mixture shown in Table 8, of dimensions and ratios of cement, mahogany fruit ash, rice husk ash, water, sand, and aggregates in proportion to the design mixture.

- Standard size of cube mold (150 mm x 150 mm x 150 mm)

1) Test Specimen Dimensions:

- *Length*: 150mm
- *Width*: 150mm
- *Height*: 150mm

Volume of each block (V) = l x w x h

So, V = 150 x 150 x 150

= 3,375,000 mm3

= 0.003375 m3

Assume mix proportions for 1 m3 of concrete based on typical ranges for standardization and simplicity.

- *Cement*: 395 kg
- *Water*: 296.25 L (w/c ratio 0.75)
- *Foam*: 43.56 kg

2) Calculations:

Wet volume = l x w x h

1 x 1 x 1 = 1 cu.m.

Cement Bags

Density of Cement 1440kg/m3

= 0.274 cu.m. x 1440 kg/m3 = 395 kg

1 bag of Cement (40kg)
= 395/40 = 9.875 bags
= say ten bags of Cement
Calculate the volume of foam.
Foam volume = 1 m³ - Cement paste volume
Foam volume = 1 m³ - 0.274 m³ = 0.726 m³
Calculate the mass of foam.
Foam mass = Foam volume × Foam density
Foam mass = 0.726 m³ × 60 kg/m³ = 43.56kg

3) Cement Quantity Per Specimen:

Cement in 1 m3 concrete = 395 kg
Volume of specimen (V) = 0.003375 m3
Cement per specimen = (395 x 0.003375) kg = 1.33 kg

4) Similarly, for Other Ingredients:

- Water per specimen = 1 L
- Foam per specimen = 150 g

Table 3
Mix design

MIXTURES	MIXTURE 1	MIXTURE 2	MIXTURE 3	MIXTURE 4
Cement (kg)	1.121kg	0.997	0.864	1.33
Rice Husk Ash (g)	133	200	266	0
Mahogany Fruit Ash (g)	67	133	200	0
Water (mL)	1	1	1	1
Foaming Agent (g)	150	150	150	150

I. Mixture 1

- *Cement*: 1.121kg
- *Water*: 1 L
- *Rice Husk Ash*: 133g (10% cement replacement)
- *Mahogany Fruit Ash*: 67g (5% cement replacement
- *Foaming Agent*: 150g

J. Mixture 2

- *Cement*: 0.931kg
- *Water*: 1 L
- *Rice Husk Ash*: 200g (15% cement replacement)
- *Mahogany Fruit Ash*: 133g (10% cement replacement)
- *Foaming Agent*: 150g

K. Mixture 3

- *Cement*: 0.731 kg
- *Water*: 1 L
- *Rice Husk Ash*: 266g (20% cement replacement)
- *Mahogany Fruit Ash*: 200g (15% cement replacement)
- *Foaming Agent*: 150g

L. Mixture 4

- *Cement*: 1.33kg
- *Water*: 1 L
- *Foaming Agent*: 150g

M. Specimen Details

This part of the study shows the details of specimen samples used to determine initial data that the researchers will use in determining the necessary test.

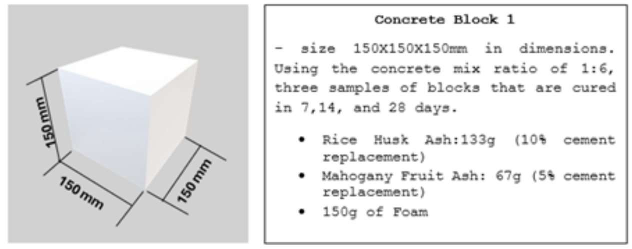

Fig. 7. Concrete block

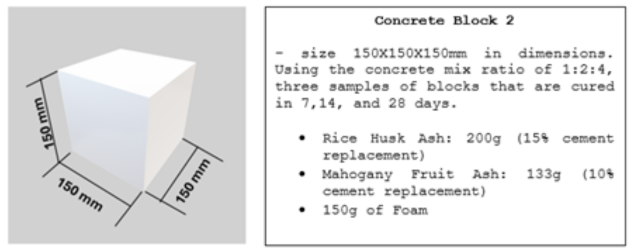

Fig. 8. Concrete block 2

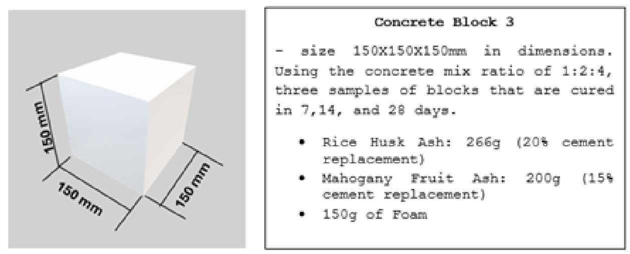

Fig. 9. Concrete block 3

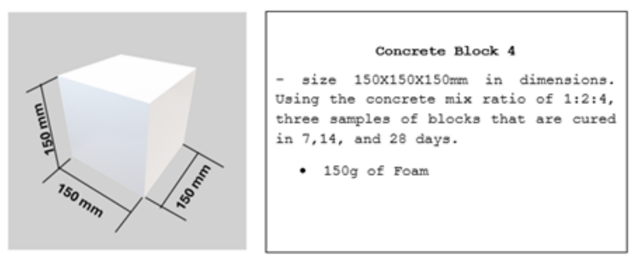

Fig. 10. Concrete block 4

N. Laboratory/Experiment/Field Experiment

1. COMPRESSIVE STRENGTH TEST
2. WATER – ABSORPTION TES
3. DENSITY TEST
4. VOID RATIO TEST

These four testing methodologies collectively provide a comprehensive evaluation framework for floating concrete formulations. While traditional concrete testing typically prioritizes strength and durability, our research repositions these tests within the context of achieving functional floating structures. The systematic analysis of compression strength, water absorption, density, and void ratio allows for evidence-based optimization of mix designs that incorporate agricultural waste materials (rice husk ash and mahogany fruit ash) with foaming agents.

The findings from these tests will inform design guidelines for floating concrete applications, particularly focusing on the effective utilization of agricultural waste materials as partial cement replacements, thereby addressing both engineering and environmental sustainability objectives.

O. Description of Research Instrument Used

This experimental research aims to determine the potential of mixing rice husk ash, mahogany fruit ash, and foaming agent to create floating concrete blocks. The instruments to be used include a concrete compression testing machine as per ASTM C39 standards to measure the compressive strength of concrete cube specimens. A weighing scale will be utilized as per ASTM C138 standards to determine the mass of concrete samples for density calculations. Water absorption testing of concrete will be carried out as per ASTM C1585 standards.

The compressive strength results of different concrete mixtures at 7, 14, and 28 days will be visually compared using bar graphs. Density values of various mix proportions will also be presented as bar charts to analyze the variation in density. Statistical analysis like mean and standard deviation will be performed on the water absorption data.

This quantitative experimental approach using statistical tools and graphical representations will facilitate a robust analysis to determine the optimal mix proportions of rice husk ash, mahogany fruit ash, and foaming agent to achieve the desired strength, density, and durability for developing floating concrete blocks from agricultural waste materials.

4. Results and Discussion

A. Compression Test of Floating Concrete Block

Using ASTM C140 as a guideline, the compression test of a single Floating Concrete Block was conducted accordingly. The load was applied at a controlled rate, based on the data of a single block with a cross-sectional area of 0.0225 m². The load was gradually applied at a rate of 0.5 to 1 MPa/s. Four specimen groups were tested, with each group consisting of 1 of the same properties.

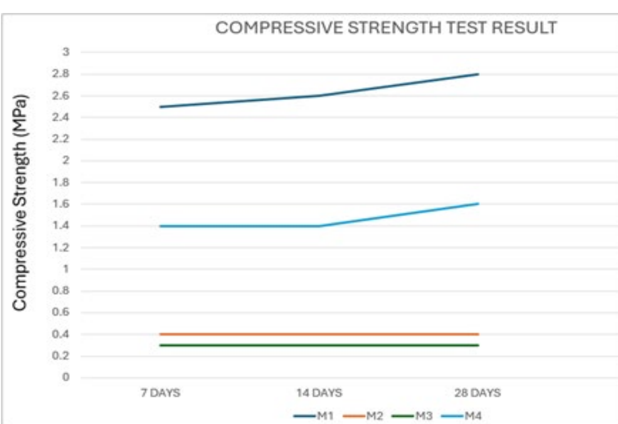

Fig. 11. Compressive strength test result

The results indicate that the compressive strength of foamed concrete decreases as the percentage of cement replacement with rice husk ash (RHA) and mahogany fruit ash (MFA) increases.

Specimen M1, which had the lowest replacement levels (10% RHA and 5% MFA), exhibited the highest strength, reaching 2.8 MPa at 28 days, demonstrating that properly proportioned agricultural waste ash can enhance concrete performance. In contrast, specimens M2 and M3, with higher replacement levels, showed significantly lower strength, with M3 recording only 0.3 MPa. Increasing ash replacement percentages resulted in significant strength reduction. Over time, M1 and M4 displayed an increase in compressive strength, with M1 improving by approximately 12% and M4 by 14% from 7 to 28 days.

However, M2 and M3 demonstrated almost no strength gain over time, indicating that excessive RHA and MFA replacement limits strength development. Interestingly, specimen M4, which contained only 133g of cement but no RHA or MFA, achieved a strength of 1.6 MPa at 28 days, outperforming both M2 and M3. This suggests that high foaming agent content has a more significant impact on strength than the total cement content. Overall, M1 proved to be the most effective mix, balancing sustainability with strength, while M2 and M3 were not structurally viable. As shown in the graph, M1 consistently has the highest compressive strength at 7, 14, and 28 days. While M4 also increases in strength, it remains lower than M1. Meanwhile, M2 and M3 had much lower compressive strengths, with just over the same period. The result shows that agricultural waste ashes can serve as effective supplementary cementitious materials when used at appropriate replacement levels. The incorporation of 10% RHA and 5% MFA produced superior concrete performance compared to both higher replacement ratios and the control mixture. These findings support the potential for agricultural waste utilization in sustainable concrete production while maintaining or enhancing mechanical properties.

B. Water- Absorption Test

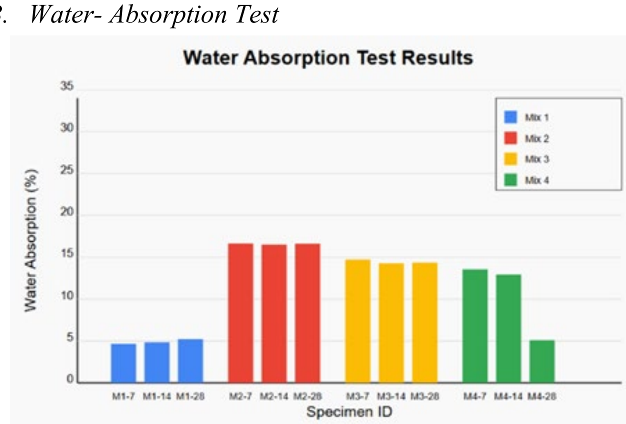

Fig. 12. Water absorption test result

The water absorption test results for four concrete mixtures containing varying proportions of rice husk ash, mahogany fruit ash, and foaming agent are presented in Figure 12.

Mixture 1 exhibited consistently low water absorption (7.31-8.47%) across all curing periods, indicating superior water resistance due to reduced interconnected porosity. This property is particularly advantageous for floating concrete applications where water impermeability is essential.

Conversely, Mixture 2 displayed the highest absorption rates (27.04-27.28%), suggesting a more porous matrix structure resulting from the specific proportions of agricultural waste materials incorporated. Mixture 3 showed intermediate absorption values (22.65-23.47%) with minimal variation across curing ages.

The most notable finding was observed in Mixture 4, which demonstrated a significant reduction in water absorption from 21.11% at 7 days to 8.21% at 28 days (61.11% decrease). This substantial improvement suggests progressive microstructural refinement through continued pozzolanic reactions between the agricultural waste components and cement hydration products.

These results demonstrate that the mixture composition and curing duration significantly influence water absorption properties of the floating concrete. While Mix 1 provides optimal immediate water resistance, Mixture 4 shows promising characteristics for applications where extended curing periods are feasible, potentially offering an effective balance between workability and long-term performance.

C. Density Test

Figure 13 shows density results for concrete mixtures M1-M4 at 7, 14, and 28 days, compared against water density (1000 kg/m³).

All mixtures-maintained densities below 1000 kg/m³, making them suitable for floating applications:

- *Mixture 1*: Highest density (947-960 kg/m³), suggesting better water resistance
- *Mixtures 2 & 3*: Similar densities (694-765 kg/m³), offering greater buoyancy but likely reduced strength
- *Mixture 4*: Showed greatest density increase over time (674 to 851 kg/m³, +26.3%), indicating microstructural refinement

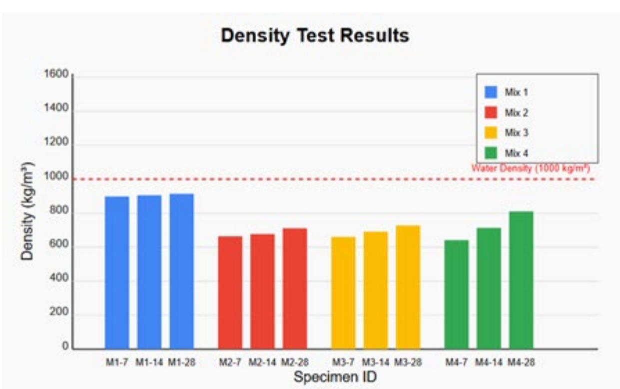

Fig. 13. Density test result

Density increased with curing age across all mixtures due to ongoing hydration reactions. For floating applications, Mixture 2 and early-age Mixture 4 provide optimal buoyancy, while Mixture 1 and mature Mixture 4 offer better balance between floating capability and mechanical performance.

D. Void Ratio Test

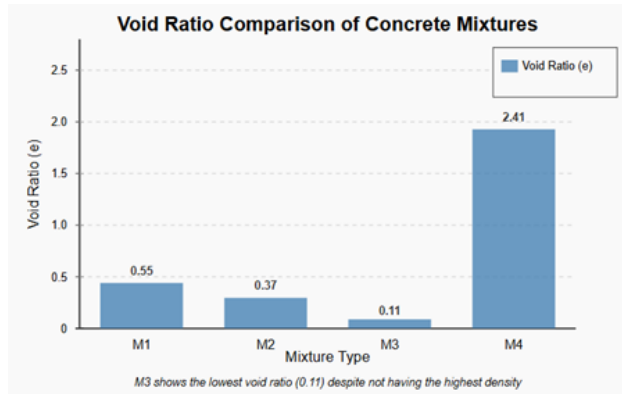

Fig. 14. Void ratio result

The calculated void ratios for the four experimental mixtures presented in Table 6, Mixture 3 exhibited the lowest void ratio (0.110), followed by Mixture 2 (0.367), Mixture 1 (0.525), and Mixture 4 (2.411).

The analysis of void ratio in foamed concrete mixtures incorporating RHA and MFA reveals that Mixture 3, with the highest combined ash content, exhibits the lowest void ratio despite not having the highest density. This phenomenon can be attributed to optimal particle packing efficiency, pozzolanic activity, and the creation of a well-graded particle size distribution.

The results demonstrate that in lightweight cementitious composites, void ratio and density don't necessarily correlate directly, as the interaction between different component materials can create complex microstructural arrangements with unique properties.

E. Cost Analysis

Theoretically, the samples involve constructing a wall having 10 m length and 3 m high using floating concrete blocks. The block dimensions are 0.15 meters (length) x 0.15 meters (height) x 0.15 meters (depth).

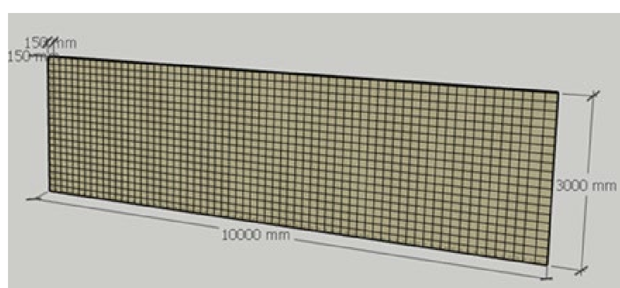

Fig. 15. 30 m² wall area using floating concrete blocks

Total wall area, Awall = 10 m x 3 m = 30 m²

Block Calculation

Block Dimension = 0.15 m x 0.15 m x 0.15 m
Area per block: 0.15 m x 0.15 m = 0.0225 m²
Total Number of Blocks Needed
= 30 m²/ 0.0225 m² per block
Total Unit Cost
Cost per block = 477php/35pcs
Cost per block = 13.63 pesos ≅ 14 pesos

1) Price Comparison of Floating Concrete Blocks with RHA and MFA to Autoclaved Aerated Concrete Blocks

Table 4
Cost comparison and difference of floating concrete and AAC blocks

	Floating Concrete Blocks with RHA and MFA	Autoclaved Aerated Concrete Blocks
Unit Cost per square meter	613.35 pesos	1,904 pesos
Price per 30 square meters	18,400.5 pesos	57,120 pesos
Price Difference per sq. m	1,290.65 pesos	
Price Difference per 30 sq. m	38,719.5 pesos	

The results in a total saving of 38,719.5 pesos when choosing for Lightweight Concrete Blocks. The cost-effective nature of Floating Concrete Blocks with RHA makes them a preferable choice for this construction project, providing a large reduction in material costs while maintaining structural integrity.

5. Conclusion and Recommendation

The study examined the effects of varying proportions of rice husk ash (RHA) and mahogany fruit ash (MFA) as partial cement replacements in foamed concrete, evaluating their impact on compressive strength, water absorption, density and void ratio. The results indicate that increasing the percentage of RHA and MFA replacement leads to a significant reduction in compressive strength. Specimen M1, which contained the lowest cement replacement (10% RHA and 5% MFA), exhibited the highest strength, reaching 3 MPa at 28 days, while specimens M2 and M3, with higher replacement levels, showed significantly lower strengths of 0.4 MPa and 0.3 MPa, respectively.

Water absorption tests revealed that specimens with higher cement replacement levels had greater porosity, with M3 displaying the highest absorption at 25% at 7 days, while M1 and M4 exhibited lower absorption rates, indicating better resistance to moisture. The density test results further supported these findings, as M1 had the highest density (959.67 kg/m³ at 28 days), whereas M3 had the lowest (694.52 kg/m³ at 7 days), confirming that increased RHA and MFA content resulted in a more lightweight but porous material.

The result in the void ratio test showed that Mixture 3 having the highest combined ash content, exhibits the lowest void ratio despite not having the highest density, which can be attributed to optimal particle packing efficiency, pozzolanic activity, and the creation of a well-graded particle size distribution. This illustrated how the interaction between various component materials can result in complex microstructural arrangements with distinct properties, meaning that void ratio and density in lightweight cementitious composites don't always correlate directly.

Overall, the results suggest that a 10% RHA and 5% MFA replacement provides the best balance between sustainability and structural performance. Higher replacement levels negatively affect strength, density, water absorption and void ratio making them less suitable for load-bearing applications. Future studies could explore the use of additives or alternative curing methods to enhance the mechanical properties of high-ash-content foamed concrete while maintaining its sustainability benefits.

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