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Optimization of Mix Proportion and Strength Properties of Lightweight Geopolymer Concrete Blocks

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Abstract:

In order to create lightweight masonry units with sufficient strength and stability, the study focuses on the development of geopolymer foam concrete (GFC) blocks. The study examines how changes in density and alkaline activator molarity affect the fresh and hardened characteristics of geopolymer foam concrete. A fly ash-based geopolymer matrix was activated using three different activator concentrations: 8 M, 10 M, and 12 M sodium hydroxide mixed with sodium silicate. To create a homogeneous cellular structure and lower overall density, an alpha-olefin sulfonate (AOS) solution was employed as the foaming agent. To find the ideal composition that offers a balance between workability, density, and strength, foamed geopolymer mixes were made at various target densities, such as 1200, 1300, and 1400 kg/m³. Workability and mix homogeneity were evaluated by measuring the qualities of fresh concrete, such as foam stability and flow. After ambient curing, the hardened specimens were examined for split tensile strength and compressive strength to determine performance patterns over molarities and densities. Determine the ideal mix ratio as well. The outcomes should demonstrate the ideal activator concentration and foam content needed to produce a lightweight geopolymer block with adequate strength (≈4–5 MPa) and improved durability, appropriate for infill and non-load-bearing wall applications.

Keywords — **Geopolymer foam concrete, activator solution, lightweight blocks, workability, compressive strength, split tensile strength**

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I. INTRODUCTION

One of the most popular building materials is concrete, but the traditional method of producing it uses a lot of natural resources and greatly degrades the environment. Researchers are looking into different binders and lightweight materials that can lower carbon emissions and resource depletion in response to the increased demand for sustainable building materials. Because geopolymer concrete uses industrial byproducts like fly ash and lowers greenhouse gas emissions, it has become a viable environmentally friendly substitute for regular Portland cement-based concrete [1]. By adding a cellular structure that lowers density without sacrificing sufficient strength, geopolymer foam concrete (GFC) further improves sustainability.

Because it enhances thermal insulation, lowers dead load, and encourages effective material use, the construction of lightweight masonry units employing GFC is especially beneficial for non-load-bearing applications. The alkaline activators, foam stability, and mix density are some of the factors that significantly influence the performance of geopolymer foam concrete [2]. Alkaline activators like sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) are essential for starting the polymerization process in geopolymer systems. The dissolution of aluminosilicate materials and the subsequent development of strength are strongly influenced by the molarity of sodium hydroxide. to earlier research, increasing molarity improves compressive strength up to a certain point, after which workability and economic viability may be impacted. Similar to this, the use of foaming agents like alpha-olefin sulfonate (AOS) contributes to the creation of a homogeneous pore structure, which lowers density while also affecting stability and strength [3]. Another crucial factor influencing the mechanical and durability characteristics of geopolymer foam concrete is its density. Higher densities boost strength at the cost of increasing weight, while lower densities improve lightweight qualities but may sacrifice strength. For practical applications, finding the ideal balance of density, workability, and strength is crucial [4]. The combined impact of alkaline activator molarity and density fluctuations in geopolymer foam concrete has received little attention, despite the fact that numerous studies have examined geopolymer concrete and foam concrete separately. Therefore, this study is to assess the fresh and hardened properties of GFC by altering target densities (1200, 1300, and 1400 kg/m³) and sodium hydroxide concentrations (8 M, 10 M, and 12 M). to identify the ideal mix composition for lightweight, non-load-bearing masonry applications by achieving appropriate strength (about 4–5 MPa), uniform foam distribution, and adequate workability [5]. Numerous scholars have examined the strength,

workability, and durability of foam concrete and geopolymer foam concrete. According to Yongcheng Ji and Qijun Sun (2022), adding carboxymethyl cellulose increases foam stability, which boosts mechanical performance and homogeneity [6]. Numerous scholars have examined the strength, workability, and durability of foam concrete and geopolymer foam concrete. According to V. Johnpaul and R. Abhirami (2022), high-strength lightweight foam concrete is suitable for both beraing and non-bearing applications, with compressive strengths ranging from 5 to 12 MPa, depending on density. According to Osman Gencel and Turhan Bilir (2022), foam concrete's density greatly influences its characteristics; a decrease in density from 1600 kg/m³ to 800 kg/m³ reduces compressive strength by around 40–60% while improving thermal insulation. Because of improved pore homogeneity [7]. Yongcheng Ji and Qijun Sun (2022) found that adding carboxymethyl cellulose (CMC) boosts compressive strength by around 10–20% and improves foam stability, According to Abdeliazim Mustafa Mohamed and Bassam A. Tayeh (2024), ultra-light foam concrete (300–800 kg/m³) has outstanding thermal insulating qualities and a compressive strength of 1–5 MPa. According to Yajun Liu et al. (2024), foam concrete's strength drops exponentially with decreasing density, although it is still appropriate for non-load-bearing applications as long as the strength is kept above 3–5 MPa [8]. Using waste resources with sufficient strength and durability, Kirubajiny Pasupathy and Sayanthan Ramakrishnan (2021) created environmentally friendly geopolymer foam concrete. According to Yun-Lin Liu and Chang Liu (2023), pore shape and strength are greatly impacted by activator concentration; larger molarity increases strength but may decrease workability [9]. According to Magdalena Rudziewicz and Marcin Maroszek (2025), foaming agents and stabilizers have a major impact on porosity and mechanical qualities; strength and durability are enhanced by increased pore dispersion. According to Sajan K.

Jose and Mini Soman (2020), foam concrete blocks with densities between 1200 and 1400 kg/m³ can reach compressive strengths of 4 to 7 MPa, making them appropriate for masonry units. The goal of this research is to examine and enhance the strength and durability performance of these waste byproducts, which not only reduces the demand for natural resource consumption but also encourages a safer method of disposing of garbage.

II. LITERATURE REVIEW

2024 Arvind Vishavkarma Due to their high air void content (between 10% and 60%) and notable void connectivity, the conventionally produced foam concretes (FCs) for lightweight applications are not appropriate for use with reinforced concrete. Designing such mixes for durability requires careful consideration because void connectivity in FCs can allow external solutions to enter their matrices and reach the steel reinforcing. The strategy is to create FCs with suitable GGBS doses and foam additives that can offer the best density and strength levels, discontinuous pore structure, and durability qualities necessary to take the place of traditional concrete. The primary objective is to comprehend how the addition of GGBS affects FC pore structure. Image analysis, scanning electron microscopy (SEM), and mercury intrusion porosity (MIP) were used to examine the pore structure characteristics of five distinct FC combinations that were made with 0%, 15%, 30%, 45%, and 60% GGBS doses in place of cement. According to the durability test results, sorptivity reduced with increasing GGBS dosage up to 30%, while water absorption, porosity, chloride ion permeation, resistivity, and drying shrinkage values decreased with increasing GGBS dosage up to 60%. The resulting macrovoids are solitary and discontinuous, according to images from SEM and image analysis. Additionally, SEM pictures show that the injection of up to 60% FCs' void structure and microstructure were enhanced by GGBS. According to the MIP data, there was a discernible drop in FC porosity up to a 30% GGBS dosage, with lower threshold and critical pore diameter values and more gel holes. However, reverse tendencies were observed in 60% of GGBS dosages. The trends found with the majority of durability tests were validated by the MIP and SEM results up to 30% and 60%, respectively. Overall, it is clear that the pore size and structure of cementitious matrices affect FC durability, and the potential. Sajan K Jose 2020 Foamed concrete, a cement-based mortar having at least 20% of its volume filled with air, is a novel and adaptable lightweight building material. The design of thin sections will result from the use of lightweight foamed concrete blocks with densities less than 1800 kg/m3 as infills. Additionally, foamed concrete blocks gained popularity in the construction business due to their ability to insulate against heat. The creation of foamed concrete building blocks for both load-bearing and non-load-bearing constructions is covered in this work. The viability of using fly ash in place of some of the cement is also investigated in order to make the mixture more environmentally friendly. Foam is one of the factors taken into account when producing foamed concrete. volume, fly ash content, water/powder ratio (a mixture of cement and fly ash), and sand/powder ratio. Additionally, an analytical model is created and verified for the dry density and compressive strength of foamed concrete while taking various factors into account. Both the dry density and the fly ash content are observed to increase with compressive strength. The addition of fly ash content is found to decrease thermal conductivity. Liu Yun-Lin (2023) This paper describes the production of an ambient-cured geopolymer foam concrete (GFC) using the chemical foaming method. The precursor was a mixture of fly ash (FA) and ground granulated blast furnace slag (GGBS), the alkaline activator was water glass, and the foaming agent was aluminum powder. The mixture design took into account the various characteristics of the alkali solution, such as Na O concentrations (ranging from 4% to 7%) and modulus ratios (ranging from 1.1 to 1.5), and the resulting properties were compared to examine their effects. The GFC's density, compressive strength, and thermal conductivity fell between 280.8 and 865.8 kg/m, 1.10 and 8.13 MPa, and 0.088 and 0.20 W/(m × K), respectively. Furthermore, a greater focus was placed on the characteristics of GFC during the foaming process, such as the gas generation rates and rheological characteristics of the geopolymer slurry, which determined the macroscopic properties of the GFC (such as density, compressive strength, and thermal conductivity) as well as the pore characteristics (such as porosity, pore size distribution, and roundness). The test findings showed that increased porosity, lower compressive strength, and worse thermal conductivity were caused by the slurry's lower viscosity and higher gas generation rate, which were produced at higher Na O concentration and lower modulus ratio.

III. METHODOLOGY

Fly ash, GGBS, alkaline activators, fine aggregate, water, and an appropriate foaming agent were among the materials needed for the study that were gathered in order to construct an experimental program. To ascertain the materials' chemical and physical characteristics, preliminary experiments were carried out. A mix design for lightweight geopolymer foam concrete was created based on these findings. To determine the ideal dosage needed to obtain the required density and stability, various trial mixes were created by altering the proportion of foaming agent. In order to achieve the perfect binder ratio and lightweight properties for foam concrete blocks, the mixes were metered. A flow table test, which assesses the mix's consistency and flowability, was used to establish the workability of new geopolymer foam concrete. Specimens of hardened concrete were cast and allowed to cure naturally. To ascertain the load-carrying capacity, the specimens' compressive strength was assessed at 7, 28, and 56 days. The geopolymer foam concrete's tensile behavior was also evaluated using the split tensile strength test.

Specimens were put through durability tests such water absorption, sulphate assault and acid resistance in order to assess their durability performance. Following exposure to hostile situations, the percentage loss in strength and weight was computed. The best mix ratio and foaming agent percentage for lightweight geopolymer foam concrete blocks were determined based on the testing findings, taking durability, strength, and workability into account.

IV. MATERIALS AND ITS PROPERTIES

A. Ground Granulated Blast Furnace Slag

ground granulated blast furnace slag (GGBS) is a commonly utilized supplemental cementitious material. It is made by quickly quenching molten slag, drying it, and then grinding it into a fine powder. In order to improve workability, durability, and long-term strength, GGBS is partially substituted for Ordinary Portland Cement (OPC) in this study. Usually, it is used with cement to create high-performance, sustainable concrete. Physical properties of Ggbs are shown in Fig 1

Fig.1 Ggbs

B. Fly Ash

Fly ash is a fine, grey powder that is left over after burning coal in thermal power plants. It is gathered from the flue gases and is mainly made up of iron oxide, silicon dioxide, and aluminum oxide. Due to its pozzolanic qualities, which cause it to solidify when combined with water, fly ash has several applications, particularly in the construction industry as an additional ingredient for concrete and cement products. Physical properties of Fly ash as shown in Fig 2

Fig.2 Fly Ash

C. M Sand

Manufactured Sand or M-Sand is a substitute of river sand, used in construction industry mainly for concrete production and mortar mix. This is mainly crushed fine aggregate produced from a source material with suitable strength, durability and shape characteristics. The physical properties were presented in table I

TABLE.I PHYSICAL PROPERTIES OF GGBS, FLY ASH AND M SAND

Materials	Specific gravity	Fineness modulus	Water absorption
Ggbs	2.45	10%	-
Fly ash	2.14	20%	-
M Sand	2.53	2.8%	1.5%

D. Sodium hydroxide (NaOH)

Strong, white, alkaline, and extremely soluble in water, sodium hydroxide (NaOH) pellets with a 97 % purity are utilized in many industrial and analytical processes. These pellets, also called caustic soda, are safer and easier to handle than its liquid or powdered counterparts. Key specifications often include limits on impurities like carbonates, chlorides, and sulfates. (Make advantage of 8M molarity) as shown in Fig 3

Fig.3 NaOH pellets

E. Sodium silicate (Na_2SiO_3)

One of the primary alkaline activators used in geopolymerization is sodium silicate, which is typically combined with sodium hydroxide (NaOH). It forms a three-dimensional geopolymeric gel (sodium aluminosilicate hydrate, or N-A-S-H gel) when it combines with aluminosilicate materials like fly ash, GGBS, or metakaolin. In conventional concrete, this gel serves as the binding agent in place of regular Portland cement are shown in Fig 4

Fig.4 Na_2SiO_3 solution

F. Foaming agent

Alpha Olefin Sulfonate, or AOS, is a synthetic surfactant that is frequently employed as a foaming ingredient in the manufacturing of foam and lightweight concrete. It lowers the overall density of the concrete mix by creating consistent and stable air bubbles. AOS increases the mix's workability and flowability without appreciably compromising its strength. During mixing and setting, the foam generated by AOS stays stable, guaranteeing uniform porosity and lightweight qualities in the finished product. It is appropriate for sustainable concrete applications because it is non-toxic, biodegradable, and eco-friendly. Better insulating qualities, less self-weight, and more affordable building materials result from the controlled usage of AOS. as shown in Fig 5

Fig.5 AOS foaming agent

G. Foam half – life (T1/2)

The time it takes for half of the liquid in a foam to drain away or for half of the foam volume to collapse is known as the foam half-life (T½). It is a crucial metric for assessing foam stability. In applications like lightweight or foam concrete, a longer foam half-life suggests that the foam is more stable and can hold its structure for a longer period of time. On the other hand, a shorter half-life causes the foam to disintegrate more rapidly, which results in uneven density and poor mix workability. As a result, the foam half-life aids in evaluating the effectiveness of foaming agents and the caliber of foam generated for concrete applications. Volume of foam = 1000 mL and foam half life test below given the table II and shown in Fig 6

TABLE.II FOAM HALF LIFE TEST

SL. NO	TIME (MIN)	AOS (gm)	AOS+CMC (gm)
1	0	36	82
2	5	33	82
3	10	32	82
4	15	30	82
5	20	30	82
6	25	30	82

Parameter	AOS (gm)	AOS+CMC (gm)
Initial mass (gm)	36	82
Final mass (gm)	30	82
Mass loss (gm)	6	0
% Retained	83.3%	100%
Foam half life (T1/2)	>20 min	>20 min

Fig.6 Foam half life test

H. Mix proportions

Selecting appropriate mixtures of aluminosilicate ingredients, such as fly ash and GGBS, activated by alkaline solutions (NaOH and Na2SiO3), is necessary to optimize mix proportions and strength characteristics of lightweight geopolymer concrete blocks. By adjusting variables including activator concentration, binder-to-aggregate ratio, and liquid-to-binder ratio, the mix design aims to replace Portland cement while striking the best possible balance between workability, density, and strength. Tests for water absorption, density, and compressive strength are used to assess the generated mixes. By using industrial by-products and minimizing the environmental effects of cement, this method promotes sustainable construction by enabling the creation of lightweight, strong, and environmentally friendly concrete

blocks. Mix proportion per m^3 mention below the table III

TABLE.III MIX PROPORTION PER M33

Material	Quality (kg/m^3)
(Ggbs + Fly ash)	400
sand	400
Activator solution	200
Foam (vol fraction)	0.45 m^3

I. Casting of specimen

Lightweight geopolymer concrete blocks were created and tested for this experimental study. Eighteen cubes (75 × 75 × 75 mm) for compressive strength were among the 48 specimens that were cast. Before casting, molds were cleaned and lightly oiled. The geopolymer mixture was put into molds in two to three layers. To maintain equal density and eliminate trapped air, each layer was crushed using a tamping rod and gentle vibration as necessary, being careful not to separate the lightweight particles A day before casting, the alkaline activator solution was made. The geopolymer blocks were not cured. After 48 hours, every specimen was demolded. until testing ages of 7, 14, and 28 days. Casting of specimen as shown in Fig 7

Fig.7 casting specimen

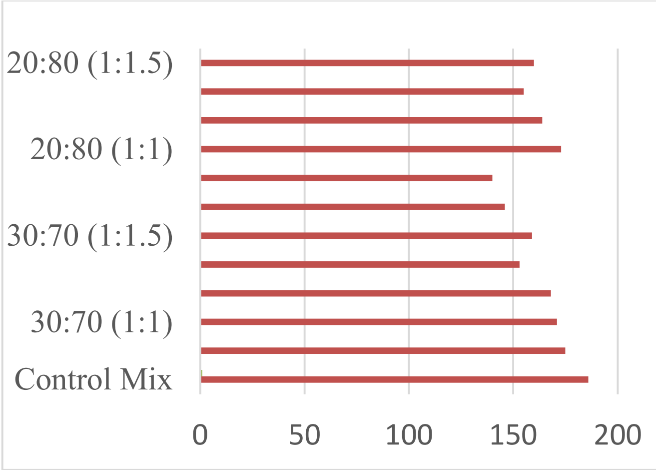

Fig.8 Flow valve vs CMC%

V. RESULTS AND DISCUSSIONS

J. Workability test

The consistency and workability of fresh concrete are assessed using the flow table test, particularly for extremely fluid mixes. Two layers of concrete are put into a conical mold and gently crushed. The table is dropped fifteen times after the mold has been lifted, allowing the concrete to spread. The flow value is calculated by averaging the spread diameter measurements made in two different directions. Better workability is shown by higher flow, whereas stiffer concrete is indicated by lower flow Carboxymethyl cellulose (CMC) contributed significantly by strengthening [6] and boosting the mix's overall performance. Usually, workability ranges from 150 to 220 mm. "A thorough analysis of foam concrete: components, characteristics, and uses" Writers: Wainwright & Kearsley (and later expanded reviews by other authors).

K. Mechanical properties

1). Compressive strength

The test was conducted in accordance with the trial mix. A 75 x 75 x 75 mm cube made of several concrete mixtures was cast and tested using a compressive testing apparatus. Because the blocks were made of lightweight geopolymer foam concrete, the specimens were stored in ambient conditions without water curing following demolding. The compressive test was performed after 7, 14, and 28 days. The experimental findings show that the binder-sand ratio, binder composition, and CMC content all have a major impact on mortar's compressive strength. Because of the larger binder content, the 1:1 mix ratio showed more strength than the 1:1.5 ratio. Because of the improved pozzolanic reaction, the 70:30 (Fly ash : GGBS) blend performed better than the other binder proportions. Additionally, the compressive strength was enhanced by the addition of CMC, with 0.10% [6]. showing the best results the outcome are shown in Fig 9. After 28 days, the mix percentage of 1:1 with a 70:30 binder ratio and 0.10 CMC produced the highest compressive strength of 4.98 N/mm². and the outcomes are shown in Fig 10

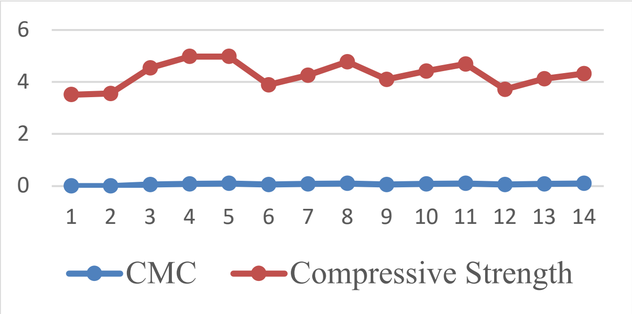

Fig.9 compressive strength vs stabilizer

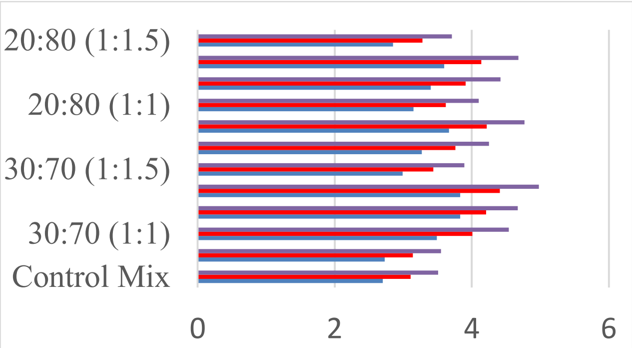

Fig 10. compressive strength of LGFC blocks

2). Split tensile strength

The tensile properties of lightweight geopolymer foam concrete were assessed using the split tensile strength test. For various mix proportions, cylindrical specimens with a diameter of 100 mm and a height of 200 mm were cast. A compression testing equipment with a 3000 kN capacity was used for the test. The load was applied along the specimen's longitudinal axis until failure occurred along its vertical diameter. Because the specimens were made of lightweight geopolymer foam concrete, they were stored under ambient conditions without water curing. The test was administered at 7, 14, and 28 days. The experimental findings show that mix proportions and additive content have a major impact on the split tensile strength of lightweight geopolymer foam concrete. Tensile strength was stronger at the 1:1 binder to sand ratio than at the 1:1.5 ratio. It was discovered that the 70:30 (Fly ash : GGBS) binder composition was ideal because of its superior bonding and reaction properties. Tensile strength was increased by the addition of CMC, with 0.08% to 0.10% showing the best results. As the curing age grew, the strength steadily increased, suggesting appropriate geopolymerization. overall, the mix proportion 1:1 with 70:30 binder ratio and 0.08–0.10% CMC is recommended as the optimum combination for achieving improved split tensile strength.

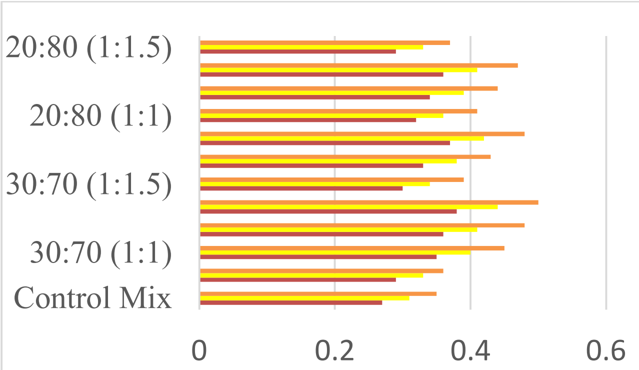

Fig 11. Split tensile strength of LGFC blocks

L. Durability test

1). Water absorption test

The purpose of the water absorption test is to assess the durability and porosity of hardened concrete. To guarantee adequate hydration and strength development, concrete cube specimens were cured in water for 28 days. The specimens were taken out of the water and surface-dried after the curing period, and their dry weight was noted. After being submerged in water for a whole day, the cubes were taken out, any surface moisture was removed, and their wet weight was determined. The percentage increase in weight compared to the dry weight was used to compute the water absorption, which revealed the porosity, density, and durability of the concrete. The outcome was represented below given table IV. According to the air-void characterisation of foam concrete, the water absorption percentage for densities between 600 and 800 kg/m3 ranges from 40 to 60%. Cement & Concrete Research, Nambiar & Ramamurthy Journal). The results of the water absorption trial show improved durability performance.

TABLE.IV WATER ABSORPTION TEST

Cube specimen	Dry wt W1 in kg	Wet wt W2 in kg	Water absorption%
Control mix	0.251	0.292	14.6
30:70 (1:1)	0.260	0.408	56.92

Fig.12 Water absorption test

2). Sulphate attack test

The purpose of the acid resistance test was to assess concrete's capacity to withstand chemical damage. To reach their maximum strength, concrete cube specimens were first cured in water for 28 days. Following curing, the cubes were weighed to determine their initial dry weight before being submerged in a 5% diluted sulfuric acid (H_2SO_4) solution for 28 days. The specimens were taken out of the acid solution at the conclusion of the immersion period, thoroughly cleaned with water to get rid of any remaining acid, surface-dried, and weighed once more. The result below a table V. A weight loss of less than 5% after 28 days of exposure to 5% H2SO4 suggests strong acid resistance (Lee et al., Construction and Building Materials).

TABLE.V SULPHATE ATTACK TEST

Cube specimen	Immersion in 5% dil H_2SO_4	Initial wt in g	Final wt in g	Wt Loss %
Control mix	28	0.243	0.238	3.79
30:70 (1:1)	28	0.262	0.249	4.96

Fig.13 Sulphate attack test

3). Chloride resistant test

The purpose of the chloride resistance test was to assess concrete's resistance to chloride ion penetration. To reach their maximum strength, concrete cube specimens were first cured in water for 28 days. Following curing, the cubes were weighed to determine their initial dry weight before being submerged in a 5% sodium chloride (NaCl) solution for 28 days. The specimens were taken out of the chloride solution at the conclusion of the immersion period, properly cleaned with clean water to remove any surface salts, surface-dried, and then weighed once more to calculate the final weight. Concrete's resistance to chloride attack was evaluated by calculating the percentage of weight loss. The result below a table VI. According to Haque and Kayali (2008), "Properties of high-strength concrete using a 5% NaCl solution exposure," the specimen subjected to 5% NaCl solution for 28 days lost 6.2% of its weight, demonstrating a modest resistance to chloride attack.

TABLE.VI CHLORIDE RESISTANT TEST

Cube specimen	Immersion in 5% dil H_2SO_4	Initial wt in g	Final wt in g	Wt Loss %
Control mix	28	0.246	0.235	3.48
30:70 (1:1)	28	0.426	0.399	6.2

Fig.14 Chloride resistant test

VI. CONCLUSION

With a focus on the effects of binder composition, binder–sand ratio, and carboxymethyl cellulose (CMC) content, the current experimental study assesses the workability, strength, and durability characteristics of lightweight geopolymer foam concrete. According to the study, these factors are important in defining the material's overall behavior and suitability for lightweight building applications

1) According to the flow table test findings, all mixtures demonstrated sufficient consistency for placement and compaction, achieving workability within the permissible range of 150–220 mm. However, because of the mix's increased viscosity, a higher CMC dosage led to a slight decrease in flowability. Despite this effect, the use of CMC improved the foam concrete's stability and homogeneity, eliminating segregation and guaranteeing cohesive mixtures.

2) The mix proportion of 1:1 (binder : sand) with a binder composition of 70:30 (fly ash : GGBS) and 0.10% CMC produced the highest compressive strength of 4.98 N/mm² at 28 days, according to the compressive strength data. The presence of GGBS, which promotes the geopolymerization process and results in the creation of a denser and more compact microstructure, is responsible for this enhancement. Fly ash and GGBS work together to improve interfacial bonding and particle packing, which increases load-bearing capacity.

3) The split tensile strength findings also show a similar pattern, with the same mix composition performing better. It was discovered that the ideal CMC level, which improves internal cohesiveness and lessens microcracking, falls between 0.08% and 0.10%. This suggests that by strengthening the integrity of the cementitious matrix and stabilizing the foam structure, CMC significantly contributes to the improvement of tensile characteristics.

4) According to durability studies, the control mix shows comparatively superior resistance to chloride penetration and water absorption, suggesting a denser structure and reduced permeability. On the other hand, mixes with a higher GGBS content (30:70 ratio) exhibited greater porosity, which resulted in somewhat higher chloride penetration and water absorption. However, these values are still within permissible bounds for applications involving lightweight foam concrete. With less than 5% weight loss, all blends were determined to have adequate sulphate resistance, indicating good tolerance to harsh environmental conditions.

5) The ideal mix proportion is determined to be 1:1 (binder : sand) with a 70:30 fly ash to GGBS ratio and 0.10% CMC based on the thorough assessment of both fresh and hardened characteristics. Workability, split tensile strength, compressive strength, and durability performance are all well balanced by this combination.

6) To sum up, lightweight geopolymer foam concrete is a practical and sustainable substitute for traditional concrete. By using industrial byproducts like fly ash and GGBS, the reliance on Portland cement is greatly reduced, which lowers carbon emissions and encourages environmentally friendly building techniques. The overall qualities stay within acceptable bounds even if there are slight decreases in workability and durability performance with increased additive content. With benefits including lower density, sufficient strength, and acceptable durability, this material thus exhibits great promise for usage in non-structural and lightweight structural applications.

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