

# The Effect of NH-1 Set Accelerator on the Fresh Properties and Mechanical Test Results of 1000 kg/m<sup>3</sup> Foam Concrete

**Ali Issa Hanfoosh**

University of Baghdad, Baghdad, Iraq  
ali.hanfush2201m@coeng.uobaghdad.edu.iq (corresponding author)

**Mohammed Zuhear Al-Mulali**

University of Baghdad, Baghdad, Iraq  
mohammed.almulali@coeng.uobaghdad.edu.iq

Received: 2 June 2025 | Revised: 17 June 2025 and 29 June 2025 | Accepted: 7 July 2025

Licensed under a CC-BY 4.0 license | Copyright (c) by the authors | DOI: <https://doi.org/10.48084/etasr.12515>

## ABSTRACT

This study investigates the effect of the NH-1 set accelerator on the fresh and hardened properties of foam concrete with a target wet density of 1000 kg/m<sup>3</sup>. Four mixes were prepared with NH-1 dosage levels of 0%, 1%, 2%, and 3% by weight of binder. The fresh and mechanical properties, including workability, setting time, compressive strength, flexural strength, and splitting tensile strength, were evaluated at 7 and 28 days. The mixed design incorporated additives to improve its stability and mechanical integrity, including a foaming agent and reinforcing fibers. The results showed that increasing the NH-1 content reduced the setting time and improved the early-age mechanical strength. The optimum performance was observed at 2% NH-1, which exhibited the highest compressive and flexural strength. The findings suggest that NH-1 effectively enhances the foam concrete performance when optimized.

*Keywords-component; formatting; style; styling; insert*

## I. INTRODUCTION

Foam concrete, also known as Cellular Lightweight Concrete (CLC), is a versatile, cement-based material recognized for its low weight, ease of placement, and excellent thermal and acoustic insulation. Its sustainable nature, due to reduced material consumption, makes it a popular choice for non-structural applications, such as void filling, floor leveling, and thermal insulation panels [1]. However, its broader use in structural applications remains limited due to challenges, like low early-age strength, slow setting times, and high porosity [2]. To address these issues, the modification of foam concrete mixtures with supplementary cementitious materials, fibers, and chemical admixtures has been explored [3]. Among these, set accelerators have gained attention for their ability to enhance hydration, reduce setting times, and improve early-age mechanical strength [4]. While various commercial accelerators have been tested in conventional and high-performance concrete, limited data exist on their effectiveness in foam concrete systems, which are more sensitive to water-to-cement ratios and internal pore structures [5]. NH-1 is a proprietary, chloride-free chemical accelerator commonly used in mortar and traditional concrete to reduce the setting time and boost the early strength. However, its performance in foam concrete, especially at specific target densities for lightweight structural or semi-structural use, has not been well studied.

Furthermore, the interaction between NH-1 and reinforcing fibers, such as Polypropylene (PP) in foam concrete remains largely unexplored. It has been shown that Polypropylene Fibers (PPF) can enhance the ductility, crack resistance, and tensile strength [6, 7], while the role of admixtures and fiber reinforcement in improving foam concrete's mechanical properties has been highlighted [8, 9]. Despite this, the combined effects of accelerators and fibers in low-density foam concrete remain uncertain. This study aims to evaluate the impact of various NH-1 dosages on the fresh and hardened properties of foam concrete with a fixed wet density of 1000 kg/m<sup>3</sup>. Specifically, it seeks to optimize key performance indicators, such as the workability, setting time, compressive strength, flexural strength, and splitting tensile strength at 7 and 28 days. The goal is to provide practical guidance for incorporating accelerators into lightweight foam concrete using conventional production methods.

## II. MATERIALS AND METHODS

### A. Cement

Ordinary Portland Cement (OPC) Type I conforming to [5] was used as the primary binder. It was sourced locally and stored in dry conditions. OPC is responsible for the strength development in foam concrete. The technical data of OPC are shown in Tables I and II.

TABLE I. CHEMICAL COMPOSITION AND MAIN COMPONENTS

Oxide compositions	Wt.%	Limits of [5]
Lime (CaO)	63.32	-----
Iron oxide (Fe <sub>2</sub> O <sub>3</sub> )	4.16	-----
Alumina (AL <sub>2</sub> O <sub>3</sub> )	5.22	-----
Silica (SiO <sub>2</sub> )	19.84	-----
Insoluble residue (IR)	0.64	Max (1.5)
Magnesia (MgO)	2.78	Max (5)
Loss on ignition (LOI)	2.68	Max (4)
Sulfate (SO <sub>3</sub> )	2.45	2.8 if C3A>3.5 2.5 if C3A≤3.5
<b>*Main components of cement</b>		
Tricalcium silicate C3S	58.91	-----
Dicalcium silicate C2S	13.11	-----
Tricalcium aluminate C3A	6.8	-----
TetraCalcium aluminate –ferrite C4AF	12.84	-----

TABLE II. PHYSICAL CHARACTERISTICS OF OPC

Propriety	Wt.%	Limits of [5]
Soundness by autoclave approach (%)	0.17	≤ 0.80
Setting time (Vicat's approach): initial setting time (min)	130 min	≥ 45 min
Setting time (Vicat's method): final setting time	260 min	≤600min
<b>Compressive strength (MPa)</b>		
Compressive strength 2 days	≥20	25.55
Compressive strength 28 days	≥ 42.5	45.48

### B. Fine Aggregates

Natural river sand was used as the fine aggregate. The sand was washed, dried, and sieved to remove the organic matter and oversized particles. Its physical and chemical properties are summarized in Tables III and IV. The sand grading falls within the acceptable limits specified in [10], and is classified under Zone 4. A constant sand-to-binder ratio was maintained across all batches to ensure a uniform foam distribution and fresh mix consistency.

### C. Water

Potable tap water was used for both mixing and curing all concrete foam mixes. The water complied with the requirements of [11], where the acceptable limits for the chemical impurities and physical characteristics in mixing water are outlined.

### D. Foaming Agent

A protein-based, preformed foaming agent was used to produce stable foam. It was diluted with water and processed through a foam generator to create uniform, fine bubbles. The resulting foam met the standards outlined in [12] for use in cellular concrete. It was added to the mortar in a controlled volume to achieve the target wet density of 1000 kg/m<sup>3</sup>.

### E. Set Accelerator (NH-1)

NH-1 is a chloride-free chemical set accelerator used to reduce the setting times and enhance the early-age strength. It was used at 0%, 1%, 2%, and 3% by weight of binder. It was dissolved in mixing water before the introduction. According to its technical datasheet, NH-1 conforms to [13].

### F. Superplasticizers

Two High-Range Water-Reducing Admixtures (HRWRAs) were utilized to enhance the mix performance. PS-1, a naphthalene-based superplasticizer from Al-Muttahida Plant, was added to improve the particle dispersion. Additionally, Sika ViscoCrete 180 GS, a polycarboxylate-based admixture, was utilized to increase the flowability and mechanical strength. Both admixtures were used in dosages ranging from 0.5% to 1% by weight of cement, following the specifications provided in [13].

### G. PPF

PPF was added at 1 kg/m<sup>3</sup> to enhance the crack resistance and matrix cohesion during the early curing stages. The fibers are monofilament-type, uniformly distributed during mixing, contributing to ductility and tensile performance. The technical data of PPF are listed in Table III, while Figure 1 illustrates the fibers.

TABLE III. TECHNICAL DATA OF PPF

Specification	Description
100 % PPF	Chemical base
0.91 g/cm <sup>3</sup>	Specific gravity
12 mm	Fiber length
18 micron-nominal	Fiber diameter
67	Aspect ratio (L/D)
Nil	Water absorption
Low	Thermal conductivity
Low	Electrical conductivity
250 m <sup>2</sup> /kg	Specific surface area of fibers
300-400 MPa	Tensile strength
~ 4000 N/mm <sup>2</sup>	Modulus of elasticity

\*Description given by the manufacturer

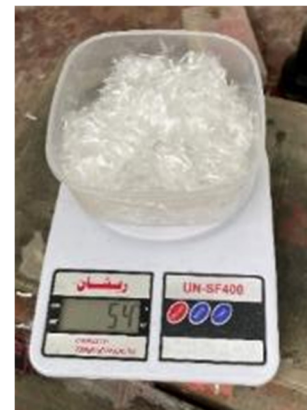


Fig. 1. PPF.

## III. MIXING AND TESTING PROCEDURES

### A. Mixing Method

All foam concrete mixes were prepared using a 500-L capacity pan mixer that had been specially modified to ensure a uniform distribution of the foam and solid materials. The mixing process followed a systematic sequence: first, the dry materials (cement and sand) were homogenized for one min. Then, the mixing water containing the superplasticizer and accelerator was gradually added and mixed for an additional

two min. After achieving a consistent mortar, the preformed foam was gently added and mixed for another min to reach the target wet density. PPF was added dry into the mortar before the foam addition, to ensure a uniform distribution without clumping.

### B. Mix Proportions

The foam concrete mixes were designed to achieve a target wet density of 1000 kg/m<sup>3</sup> and a dry density of approximately 900 kg/m<sup>3</sup>. A constant water-to-binder ratio (w/b) of 0.45 and a sand-to-binder ratio of 1:1.22 were maintained across all mixes. A fixed cement content of 400 kg/m<sup>3</sup> was used. Four separate mixes were prepared by varying the NH-1 accelerator dosage at 0%, 1%, 2%, and 3% by weight of the binder. The mix design aimed to evaluate the influence of the accelerator on both the early-age and long-term mechanical and physical properties of the lightweight foam concrete, as detailed in Table IV.

TABLE IV. FOAM CONCRETE MIX PROPORTIONS FOR 1000 kg/m<sup>3</sup> DENSITY

Component	Quantity per m <sup>3</sup>
Cement (kg)	400
Sand (kg)	488
Mixing water (L)	180
PS-1 (wt.% of cement)	1%
NH-1 (wt.% of cement)	0%, 1%, 2%, 3%
PPF (kg)	0.6
Foam (approx. L)	As needed to reach 1000 kg/m <sup>3</sup>

### C. Casting and Curing

The fresh foam concrete was cast into standard cubes and cylindrical molds designed for mechanical property testing. The molds were filled and lightly hand-tamped to maintain uniformity without collapsing the foam structure. After 24 h, the specimens were demolded and cured under standard laboratory conditions (23 °C ± 2 °C and relative humidity above 95%) until the designated testing age, as illustrated in Figure 2.



Fig. 2. Molds for foam concrete specimens.

## IV. TESTING PROGRAM

### A. Compressive Strength Test

The compressive strength was evaluated using 100 mm cube specimens tested under a universal testing machine. A constant loading rate of 0.5 MPa/s was applied until failure. The test was conducted according to [14]. All specimens were cured in water and tested at 7 and 28 days. The average strength from three samples was reported for each mix.

### B. Flexural Strength Test

The flexural strength was determined by using prismatic specimens (100 mm × 100 mm × 400 mm) under third-point loading. The test followed the guidelines of [15], applying load at a steady rate until failure. The flexural strength provides insight into the material's ability to resist the bending and crack propagation.

### C. Splitting Tensile Strength Test

The splitting tensile strength was measured using cylindrical specimens (100 mm diameter × 200 mm height). The test was conducted according to [16] by applying a diametral compressive load to induce tension along the vertical axis. This test evaluates the tensile capacity and crack resistance of the foam concrete matrix.

### D. Dry Density Test

To determine the dry density, the specimens were dried in an oven at 105 °C ± 5°C until a constant mass was achieved. The density was calculated by dividing the dry weight by the specimen's volume [17].

### E. Water Absorption Test

Dried specimens were immersed in water for 48 h. The difference between wet and dry weights was used to calculate the water absorption, following the guidelines of [18]. This method assesses the porosity and durability characteristics of the foam concrete.

## V. RESULTS AND DISCUSSION

The experimental results for lightweight foam concrete with a target density of 1000 kg/m<sup>3</sup> are presented in Tables V and VI. The average values for the compressive strength, flexural strength, splitting tensile strength, water absorption, and dry density at 7 and 28 days of curing are demonstrated. The impact of varying NH-1 accelerator dosages (0%, 1%, 2%, and 3%) is displayed. These results provide a basis for assessing the mechanical properties and durability of the foam concrete mixtures.

TABLE V. MECHANICAL AND PHYSICAL PROPERTIES OF FOAM CONCRETE MIXES AT 7 DAYS

Mix ID	NH-1 %	Age	Compressive	Flexural	Tensile	Water absorption test	Density
			(MPa)	(MPa)	(MPa)	%	kg/m <sup>3</sup>
A10-C	0	7 days	2.51	0.48	0.576	8.84	729
A10-1	1	7 days	3.11	0.65	0.653	8.13	723
A10-2	2	7 days	4.63	1.08	0.757	5.90	716
A10-3	3	7 days	3.48	1.01	0.708	7.54	719

TABLE VI. MECHANICAL AND PHYSICAL PROPERTIES OF FOAM CONCRETE MIXES AT 28 DAYS

Mix ID	NH-1 %	Age	Compressive strength	Flexural strength	Tensile strength	Water absorption test	Density
			(MPa)	(MPa)	(MPa)	%	kg/m <sup>3</sup>
A10-C	0	28 days	2.59	0.55	0.584	8.39	697
A10-1	1	28 days	3.11	0.71	0.661	7.98	695
A10-2	2	28 days	4.82	1.09	0.797	5.89	699
A10-3	3	28 days	3.84	1.01	0.708	7.52	688

A. Compressive Strength

At 28 days, the compressive strength of the foam concrete increased with the NH-1 dosage. The mix with 2% NH-1 achieved the highest strength (4.82 MPa), followed by the 3% mix (3.84 MPa), the 1% mix (3.11 MPa), and the control mix (2.59 MPa). This performance is attributed to improved cement hydration and matrix development, supporting the findings in [19]. Figure 3 illustrates the compressive strength development at both 7 and 28 days.

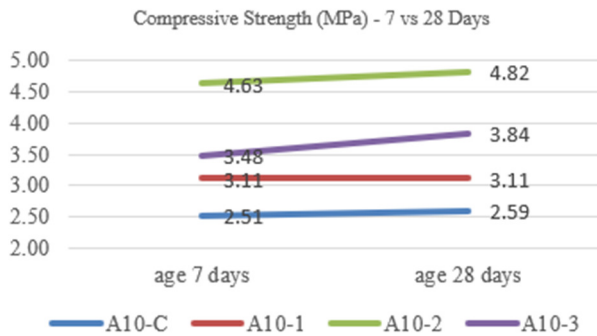


Fig. 3. Compressive strength at 7 and 28 days.

B. Flexural Strength

The flexural strength also showed a consistent improvement. The highest value was recorded for the 2% NH-1 mix (1.09 MPa), followed by 3% (1.01 MPa), 1% (0.71 MPa), and the control (0.55 MPa). This confirms that NH-1 enhances the bonding and reduces the microcracks [20, 21]. The flexural strength comparison can be seen in Figure 4.

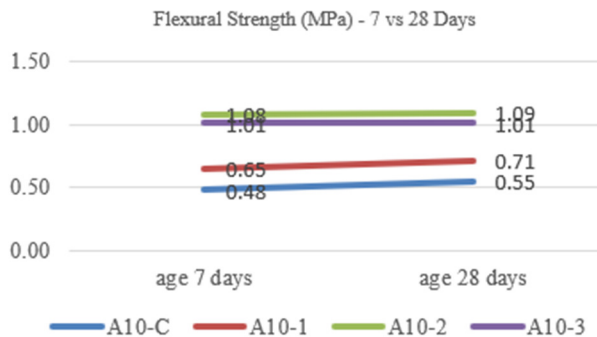


Fig. 4. Flexural strength at 7 and 28 days.

C. Splitting Tensile Strength

The mix containing 2% NH-1 achieved the highest splitting tensile strength (0.797 MPa), whereas the control mix showed the lowest value (0.584 MPa). This supports the findings in [22, 23], which indicate that admixtures can enhance the matrix integrity, leading to an improved tensile performance. These results are portrayed in Figure 5.

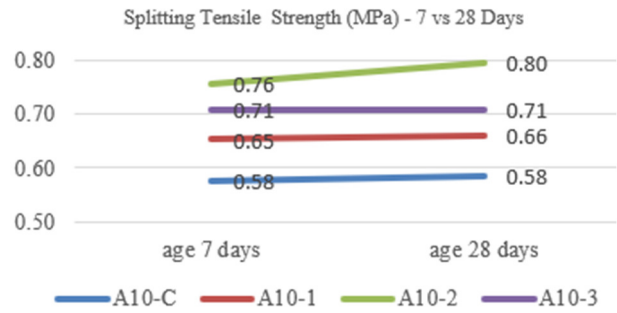


Fig. 5. Splitting tensile strength at 7 and 28 days.

D. Water Absorption

NH-1 significantly reduced the water absorption in the foam concrete mixes. The mix with 2% NH-1 had the lowest absorption rate (5.89%), indicating decreased pore connectivity, while the control mix had the highest (8.39%). These results suggest an enhanced durability, complying with the findings in [24], as exhibited in Figure 6.

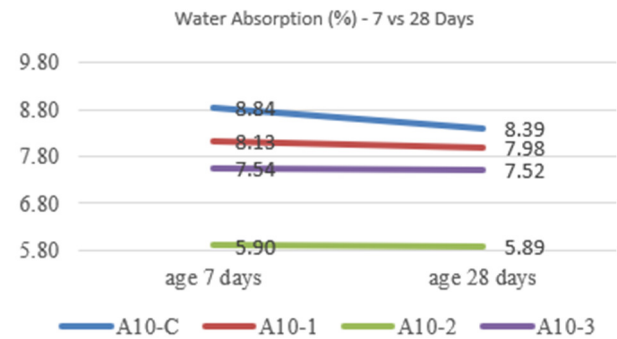


Fig. 6. Water absorption at 7 and 28 days.

E. Dry Density

The dry density values were slightly varied, ranging from 688 to 729 kg/m<sup>3</sup>. The 2% NH-1 mix achieved one of the highest densities (699 kg/m<sup>3</sup>), indicating a more compact internal structure and efficient particle packing, as also demonstrated in Figure 7 [25].

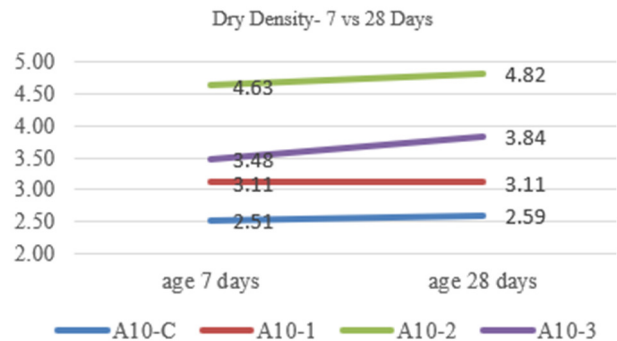


Fig. 7. Dry density at 7 and 28 days.

## VI. CONCLUSIONS

This study aimed to enhance the fresh and hardened properties of lightweight foam concrete, targeting a wet density of 1000 kg/m<sup>3</sup>, by incorporating the NH-1 setting accelerator. The research addresses key limitations of foam concrete, such as slow setting times, low mechanical strength, and high water absorption, which have hindered its broader structural use. An experimental program was conducted using varying NH-1 dosages, and standardized tests were performed to evaluate the compressive strength, flexural strength, splitting tensile strength, water absorption, and dry density at 7 and 28 days. Among the tested mixtures, the mix containing 2% NH-1 by binder weight consistently delivered the best performance. This mix achieved a 28-day compressive strength of 4.82 MPa, an 86% improvement over the control mix. Comparable enhancements were observed in the flexural and splitting tensile strengths, indicating improved matrix integrity and greater resistance to cracking. Additionally, the water absorption rate decreased by approximately 30%, suggesting a denser, less permeable microstructure, which contributes to long-term durability. The slight increase in the dry density, achieved without compromising workability, points to better foam stability and more uniform particle distribution. Compared to earlier studies that used additives, such as fly ash or silica fume, which yielded only modest strength gains, this study demonstrates more substantial improvements in both the strength and durability. The findings confirm NH-1's dual role in accelerating the setting time and enhancing the structural performance of foam concrete. Based on these results, a 2% NH-1 dosage is proposed as the optimal amount to improve the strength, durability, and reliability in foam concrete applications. This research contributes to the development of more effective lightweight concrete mixes, laying the groundwork for future field applications and durability studies.

## REFERENCES

- [1] B. Raj, D. Sathyan, M. K. Madhavan, and A. Raj, "Mechanical and durability properties of hybrid fiber reinforced foam concrete," *Construction and Building Materials*, vol. 245, Jun. 2020, Art. no. 118373, <https://doi.org/10.1016/j.conbuildmat.2020.118373>.
- [2] X. G. Yu *et al.*, "Influence of Testing Methods on Setting Time of Foam Concrete," *Advanced Materials Research*, vol. 177, pp. 514–517, 2011, <https://doi.org/10.4028/www.scientific.net/AMR.177.514>.
- [3] J. Wei, T. Wang, Y. Zhong, Y. Zhang, and C. K. Y. Leung, "Performance Evaluation of Foamed Concrete with Lightweight Aggregate: Strength, Shrinkage, and Thermal Conductivity," *Materials*, vol. 17, no. 15, Jan. 2024, Art. no. 3869, <https://doi.org/10.3390/ma17153869>.
- [4] D. Zhang *et al.*, "Development of a Novel Type of Liquid Accelerator Based on Aluminum Sulfate and Its Accelerating Mechanism for Cement Hydration," *Journal of Materials in Civil Engineering*, vol. 36, no. 1, Jan. 2024, Art. no. 04023517, <https://doi.org/10.1061/JMCEE7.MTENG-16404>.
- [5] *IQS No. 5/2019 Portland Cement*. Iraq: Iraqi Standard Specification, 2019.
- [6] M. Badawi, A. G. Ahmed, T. A. Eldamaty, and M. M. Helal, "The Effect of Polypropylene Fibers on the Fracture Characteristics of Lightweight Aggregate Crumb Rubber Concrete Composites," *Engineering, Technology & Applied Science Research*, vol. 13, no. 3, pp. 10638–10645, Jun. 2023, <https://doi.org/10.48084/etasr.5821>.
- [7] G. Zhou and R. K. L. Su, "A Review on Durability of Foam Concrete," *Buildings*, vol. 13, no. 7, Jul. 2023, Art. no. 1880, <https://doi.org/10.3390/buildings13071880>.
- [8] S. K. Shill, E. O. Garcez, S. Al-Deen, and M. Subhani, "Influence of Foam Content and Concentration on the Physical and Mechanical Properties of Foam Concrete," *Applied Sciences*, vol. 14, no. 18, Jan. 2024, Art. no. 8385, <https://doi.org/10.3390/app14188385>.
- [9] R. J. Sldozian, A. G. Tkachev, I. V. Burakova, and Z. A. Mikhaleva, "Improve the mechanical properties of lightweight foamed concrete by using nanomodified sand," *Journal of Building Engineering*, vol. 34, Feb. 2021, Art. no. 101923, <https://doi.org/10.1016/j.jobe.2020.101923>.
- [10] *Iraqi Specifications No. (45), 1984 for Aggregates of Natural Resources used for Concrete and Construction*. Iraq: Iraqi Standard Specification, 1984.
- [11] *Iraqi Standard Specification, No. 1703, Water used in concrete*. Iraq: Iraqi Standard Specification, 1992.
- [12] *ASTM C796-97 Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam*. USA: ASTM International, 1997.
- [13] *ASTM C494/C494M-19e1 Standard Specification for Chemical Admixtures for Concrete*. USA: ASTM International, 2019.
- [14] *BS EN 12390-3:2019 Testing hardened concrete Part 3: Compressive strength of test specimens*. UK: British Standards Institution, 2019.
- [15] *BS EN 12390-6:2009 - Testing Hardened Concrete Part 6 - Tensile Splitting Strength of Test Specimens*. UK: British Standards Institution, 2009.
- [16] *BS EN 12390-5:2009 Part 5 Flexural Strength of Test Specimens*. UK: British Standards Institution, 2009.
- [17] *BS EN 12390-7:2019 Testing hardened concrete Part 7: Density of hardened concrete*. UK: British Standards Institution, 2019.
- [18] *BS 1881-122:1983 Testing concrete - Method for determination of water absorption*. UK: British Standards Institution, 1983.
- [19] H. Awang, Z. S. Aljoumaily, N. Noordin, and M. Z. Al-Mulali, "The Mechanical Properties of Foamed Concrete containing Un-processed Blast Furnace Slag," *MATEC Web of Conferences*, vol. 15, 2014, Art. no. 01034, <https://doi.org/10.1051/mateconf/20141501034>.
- [20] M. Amran *et al.*, "Fibre-Reinforced Foamed Concretes: A Review," *Materials*, vol. 13, no. 19, Sep. 2020, Art. no. 4323, <https://doi.org/10.3390/ma13194323>.
- [21] R. K. M. Jawad, M. J. Kadhim, and H. M. Kamal, "A Review of The Effect of Additives on the Mechanical Properties of Lightweight Concrete," *Journal of Engineering and Sustainable Development*, vol. 27, no. 6, pp. 713–724, Nov. 2023, <https://doi.org/10.31272/jeasd.27.6.4>.
- [22] E. P. Kearsley and P. J. Wainwright, "The effect of high fly ash content on the compressive strength of foamed concrete," *Cement and Concrete Research*, vol. 31, no. 1, pp. 105–112, Jan. 2001, [https://doi.org/10.1016/S0008-8846\(00\)00430-0](https://doi.org/10.1016/S0008-8846(00)00430-0).
- [23] E. Namsone, G. Šahmenko, and A. Korjakins, "Durability Properties of High Performance Foamed Concrete," *Procedia Engineering*, vol. 172, pp. 760–767, 2017, <https://doi.org/10.1016/j.proeng.2017.02.120>.
- [24] N. Narayanan and K. Ramamurthy, "Structure and properties of aerated concrete: a review," *Cement and Concrete Composites*, vol. 22, no. 5, pp. 321–329, Oct. 2000, [https://doi.org/10.1016/S0958-9465\(00\)00016-0](https://doi.org/10.1016/S0958-9465(00)00016-0).
- [25] A. W. Ali and N. M. Fawzi, "Production of Light Weight Foam Concrete with Sustainable Materials," *Engineering, Technology & Applied Science Research*, vol. 11, no. 5, pp. 7647–7652, Oct. 2021, <https://doi.org/10.48084/etasr.4377>.