

# Experimental Study on Engineering Properties of Foam Concrete Using Natural Foaming Agent-Soap Nut

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**Abstract:** *The construction industry's contribution to global sustainability efforts necessitates exploring eco-friendly alternatives for building materials. This study investigates the impact of natural foaming agents on the engineering properties of foam concrete, with a focus on environmental considerations aligned with global sustainability goals. Foam concrete, a lightweight material without coarse aggregate, relies on the type of foaming agent used. This paper presents a study on the effects of natural foaming agents on foam concrete's engineering properties, including compressive strength, water absorption, and density. Experimental results indicate that foam concrete produced with a natural foaming agent exhibits greater compressive strength and density while absorbing less water. These findings contribute to reducing the dead load on structures and minimizing labor costs during construction.*

**Keywords:** *soap nut, water absorption, compression, density*

## 1. INTRODUCTION:

Foam concrete, also known as Lightweight Cellular Concrete (LCC) or low-density Cellular Concrete (LDCC), is a cement-based slurry with a minimum of 20% foam entrained into the plastic mortar. Typically devoid of coarse aggregate, foam concrete's density varies from 400 kg/m<sup>3</sup> to 1600 kg/m<sup>3</sup>, controlled by substituting fine aggregate with foam. Its origins trace back to the early 1920s with the production of autoclaved aerated concrete primarily for insulation. The composition, physical properties, and production of foamed concrete were extensively studied in the 1950s and 60s, leading to commercial use in the late 1970s. Foam concrete has since found diverse applications, notably in the Netherlands for void filling and ground stabilization. Recent advancements include its production with a continuous foam generator, resulting in fireproof, insect-proof, and waterproof material offering thermal and

acoustic insulation. This versatile construction material finds use in various applications including foundations, subfloors, building blocks, walls, domes, and arches.

## 2. MATERIALS

**Natural Foaming Agent:** Soap nut pericarp (200g) boiled in 2 liters of water for 30 minutes, cooled to room temperature, and used for foam preparation.

**Cement:** 53-grade Ordinary Portland Cement (OPC) used for foam concrete production with tests conducted to determine its properties such as fineness, specific gravity, and setting time.

**Fly Ash:** A Byproduct of coal combustion is used as a partial replacement for cement to enhance strength and durability.

**Gypsum:** Occasionally used in small amounts to improve foam concrete properties such as workability, setting time, and water retention.



Fig1: Soap Nuts (Natural Foaming Agent)

## 3. EXPERIMENTAL INVESTIGATION

Foam rise and stability are crucial for achieving the desired density and strength in lightweight concrete. Foam rise tests were conducted for natural and synthetic foaming agents to optimize mix proportions. Tables 1 and 2 present foam rise test reports for natural and synthetic foaming agents, respectively, detailing parameters such as foaming agent percentage, foam retention, and expansion rate.

Table 1: Foam Rise Test Values – Natural Foaming Agent

w/c ratio	% of F A	Foaming Agent			Foam Retention (min)	Foam withstands after 30 min(cm)
		Initial Stage(cm)	Final stage (cm)	Foam Rise (cm)		
	0.5	0.8	3	2.2	2	
0.4	0.7	0.8	13	12.2	15	
	0.9	0.8	14	13.2	33	7

	1.1	0.8	13.5	12.7	75	12
0.45	0.5	1	10	9	25	
	0.7	1	12	11	35	3
	0.9	1	14	13	65	11
	1.1	1	13	12	90	10
0.5	0.5	1.2	12	10.8	30	
	0.7	1.2	15	13.8	40	10
	0.9	1.2	17.5	16.3	70	14
	1.1	1.2	14	12.8	95	13

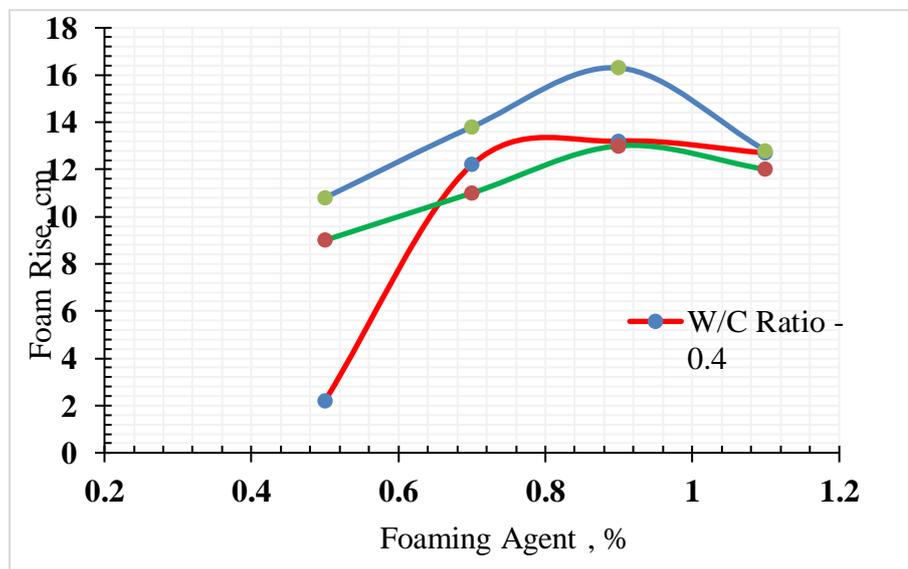


Fig 2: Relationship between Foaming Agent and Foam Rise

Fig 2 shows the relationship between Foaming Agent and Foam Rise for various W/C ratios, where it shows foam rise to 0.9% and decreased at 1.1%

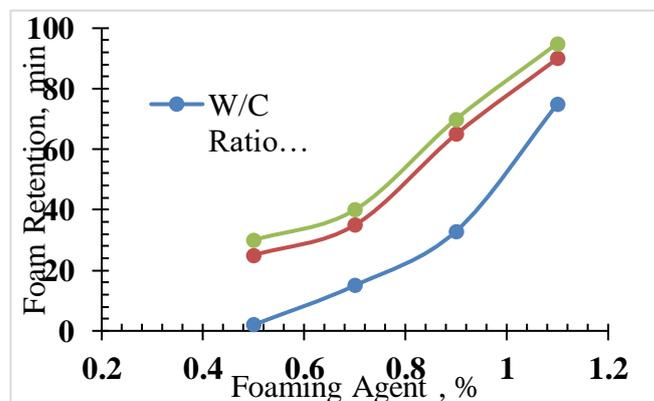


Fig 3: Relationship between the percentage of Foaming Agent and Foam Retention.

Fig 3 shows the percentage of Foaming Agent and Foam Retention for various water-cement ratios, where it shows when compared with 0.5% the Retention time of Foam increases to 0.7%,0.9%, and 1.1%.



Fig:4Foam Retention



Fig:5 Measuring Foam Rise

#### 4. MIX DESIGN:

The mix design process involves selecting concrete ingredients and determining their proportions to achieve the desired strength and durability economically. This study employed a trial-and-error method for mix design, considering various combinations to test foam concrete's engineering properties.

a. Cement + Water + Gypsum + Fly Ash +(Foam) Natural Foaming Agent

##### 4.1 Mix Proportion

The ratio for synthetic foaming agents was obtained in the journal, “Characteristics of lightweight concrete based on a Synthetic Polymer Foaming Agent” published by Marta Kadela Alfred Kukielka and Marcin Malek in 2020. Foam concrete can be obtained from the trial-and-error method by maintaining low density and workability.

##### The ratio used for Natural Foaming Agent

Cement: water: Foaming agent (Natural) -1: 0.4: 0.008

##### 4.2 Preparation of Foam Concrete (Natural and Synthetic)



Fig: 6 Generating Foam



Fig: 7 Mixing Cement and Foam



Fig: 8 Casting of Cubes



Fig: 9 Mix Poured in Mould



Fig: 10 Cubes after demolding

## 5. PROPERTIES OF FOAM CONCRETE:

Compression tests, water absorption tests, and density tests were conducted to evaluate foam concrete's properties. Tables and figures present test results of natural foaming agents.

Table 2: Compression Test Results – Foam Concrete (Natural Foam concrete)

Ratio/ W/C 0.45	% Of FA	Days	Volume (m <sup>3</sup> )	Cross- sectional Area(A) (mm <sup>2</sup> )	Crushing load (P)	Compressive Strength (N/mm <sup>2</sup> )	% increase in strength
1:0.9:0.1 C: Fl A: G	0.7	28	0.002136	22500	100.5	4.45	
	0.9	28	0.002136	22500	122.7	4.97	<b>11.6</b>
	1.1	28	0.00225	22500	77.8	3.45	<b>-22.4</b>

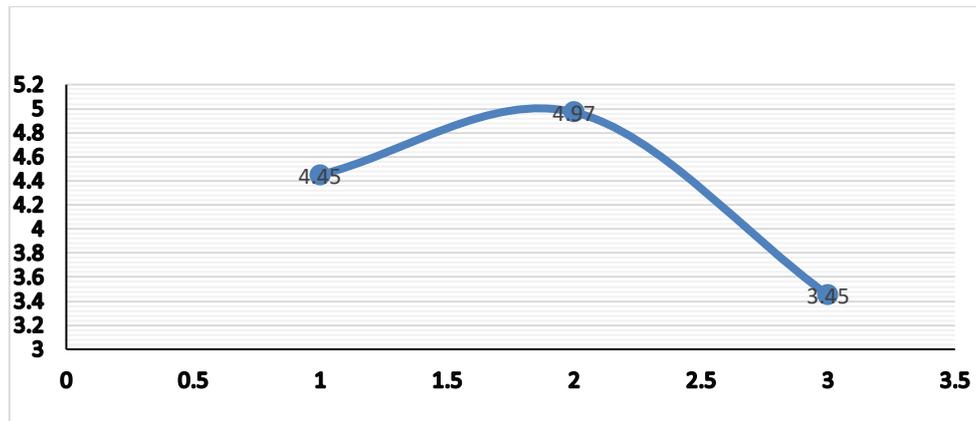


Fig:11 Compressive Strength of NFC - 28 days with various Ratios

Fig:11 shows the compressive strength of Foam Concrete with Natural Foaming Agent for 28 days where the compressive Strength increased to 0.9% percentage and started decreasing when 1.1% of the foaming agent was added to the mix.



Fig:12 Compression Test – UTM

### WATER ABSORPTION

Table 3: Water Absorption of Natural Foam Concrete

Ratio/ W/C 0.45	% FA	Days	Dry Weight of Cube (kg)	Wet Weight of cube	% of Water Absorption	% decrease
1:0.9:0.1 C: Fl A: G	0.7	28	3.642	3.780	3.7	-
	0.9	28	3.762	3.812	1.3	-2.4
	1.1	28	3.469	3.570	2.9	-1.6

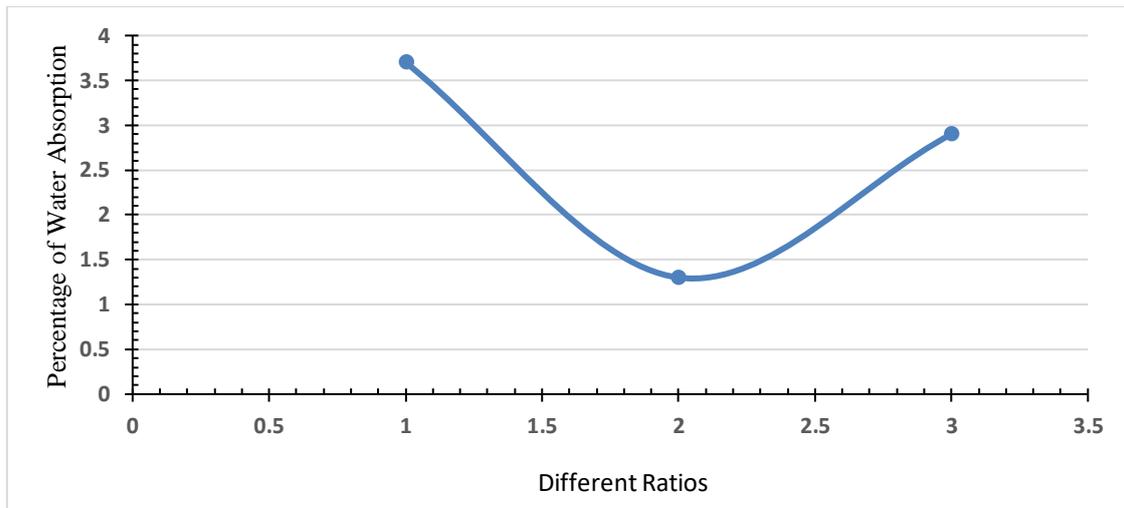


Fig: 13 Water Absorption for NFC at different Ratios – 28 Days

Fig 12 shows 1.3 % of water was absorbed by Natural Foam Concrete when 0.9% of Foaming agent was added which is less when compared to 0.7 % and 1.1%.



Fig 14: Water Absorption of Cube -24 hours

### DENSITY TEST

Various Density has been achieved using different % of Foaming Agent which range from (700-1200kg/m<sup>3</sup>)

Table 4: Density of Foam Concrete – Natural Foaming Agent

Ratio/28 Days	%FA	Volume of the cube (m <sup>3</sup> )	Weight (kg)	Density of the cube (kg/m <sup>3</sup> )
1:0.9:0.1 C: Fl A: G	0.7	0.002136	3.642	1705.05
	0.9	0.002136	3.762	1762.8
	1.1	0.00225	3.469	1541.7

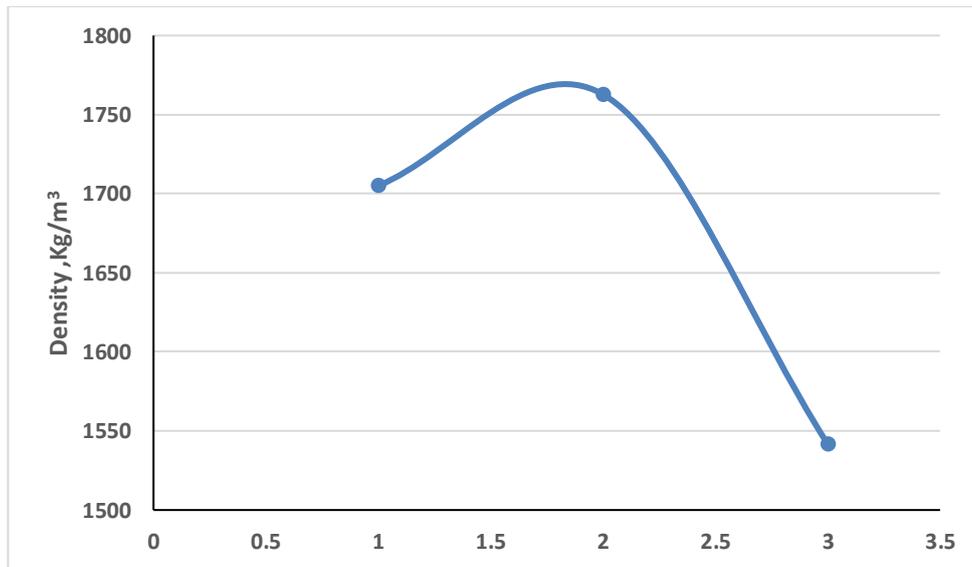


Fig 15: Density of NFC for Various Ratios

Fig 15 shows NFC for various ratios using different % of Foaming Agent.

## 6. CONCLUSION:

Based on the experimental results the following conclusions are drawn.

- The optimum percentage of natural foaming agents used to prepare foam concrete is 0.9%.
- When foam concrete absorbs more water, compressive strength decreases.
- When the Foam Concrete's density increases, compressive Strength also increases.
- The compressive strength of foam concrete using 0.9% Natural foaming agent is 11.6% greater in strength when compared to 0.7% and 11.2% greater when compared to 1.1%.

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