Research study on Structural Stability and Strength Analysis of Lightweight Cellular Concrete

Mr. Shankar Maryappa Dawane[1], Prof. Vaibhav Vilas Shelar[2], Prof. Vijay Shivaji Shingade[3]
[1]*Student, ME Structural Engineering, Trinity College of Engineering and Research, Pune, India*
[2,3]*Professor, Dept. of Civil Engineering, Trinity College of Engineering and Research, Pune, India*

***Abstract*— Concrete is most important construction materials. Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate that is bonded together by cement and water. Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. This research was based on the performance of aerated lightweight concrete. Lightweight Cellular Concrete (LCC), known for its low density and thermal insulation properties, is increasingly used in modern construction. However, concerns remain regarding its structural stability and mechanical strength, especially when modified with foam agents and recycled materials. The incorporation of waste crushed CLC (Cellular Lightweight Concrete) blocks as a partial replacement for fine aggregates presents a sustainable solution to construction waste, but its impact on the structural performance of LCC is not fully understood. This study aims to analyze the structural stability and strength characteristics of LCC modified with varying proportions of foam agent and crushed CLC waste, to determine optimal mix ratios that balance sustainability with performance.**

***Index Terms*— CLC, Lightweight Cellular Concrete, waste, foam agents**

I. INTRODUCTION

Concrete is most important construction materials. Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate that is bonded together by cement and water. In upcoming years there has been an increasing worldwide demand for the construction of buildings, roads and an airfield which has mitigate the raw material in concrete like aggregate. In some ruler areas, the huge quantities of aggregate that have already been used means that local materials are no longer available and the deficit has to be made up by importing materials from other place. Therefore, a new direction towards Cellular Lightweight Concrete in building and civil engineering construction is used.

Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. This research was based on the performance of aerated lightweight concrete. However, sufficient water cement ratio is vital to produce adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles, thus loss in strength of concrete. Likewise, too much water can cause cement to run off aggregate to form laitance layers, subsequently weakens in strength.

A. Applications of Cellular Lightweight Concrete

1) Building Blocks: Blocks and panels can be made for partition and load bearing walls. They can be made with almost any dimensions.

2) Floor Screed: Foamed concrete can be used for floor screeds, creating a flat surface on uneven ground and raising floor levels.

3) Roof Insulation: Foamed Concrete is used extensively for roof insulation and for making a slope on flat roofs. It has good thermal insulation properties and because it is lightweight foamed concrete does not impose a large loading on the building.

4) Road Sub-Base: Foamed Concrete is being used road sub base on a bridge. Foamed concrete is lightweight so that the loading imposed on the bridge is minimized.

B. CLC Waste Block

Cellular Light Weight Concrete (CLC) is also known as a Foam Concrete. Cellular Light Weight Concrete (CLC) is a very light in weight that is produced like normal concrete under ambient conditions. CLC

Blocks area cement bonded material made by blending slurry of cement. It very lightweights with density ranging from 300 to 1800 kg/m3. Which was three times less weight than fly ash or clay brocks. It is Environment-friendly. Foam concrete is made by eco-friendly material as fly ash and other industrial waste material are used in part of manufacturing blocks to protect the environment. The production process of Foam concrete or its use does not release any harmful effluents to water, ground or air.

Fig 1 CLC Waste Block

C. Concrete Foaming Agent

A concrete foaming agent is a chemical substance used to produce foam in concrete, resulting in a lightweight and insulating material. The foam is typically created by mixing the foaming agent with water and air, which is then incorporated into the concrete mix. This process helps in reducing the overall weight of the concrete while maintaining its structural integrity and providing additional benefits like thermal and acoustic insulation. Marjanol Concrete Foaming Agent is a specific brand of concrete foaming agent designed to create lightweight and durable foamed concrete. Like other foaming agents, it is used to produce foam, which is incorporated into concrete to reduce its density while maintaining essential properties like strength and insulation

Fig 2 Marjanol Foaming Agent- (389 Rs / liter)

II. METHODOLOGY

Foaming Agent (%): Seven different foaming agent percentages are considered (0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, and 1.5%). Each sample is prepared by incorporating different amounts of foaming agent into the cement-based slurry, ensuring the foam is well-distributed throughout the mix.

Table 1. Mix proportion for Foaming Agent

Percentage of Foaming agent (%)	Cement (kg)	Sand (kg)	Aggregates (kg)	Water ml	Foaming agent ml
0%	1.8	2.85	5.82	810	0.00
0.25%	1.8	2.85	5.82	808	2.03
0.50%	1.8	2.85	5.82	806	4.05
0.75%	1.8	2.85	5.82	804	6.08
0.1%	1.8	2.85	5.82	809	0.81
1.25%	1.8	2.85	5.82	800	10.13
1.5%	1.8	2.85	5.82	798	12.15

Waste CLC as Aggregate (%): Seven different percentages of waste CLC as aggregate are used (0%, 10%, 15%, 20%, 25%, 30%, and 35%). The waste CLC is added as a partial replacement for natural aggregates to assess its effect on the overall performance of the concrete

Table 2. Mix proportion for Waste CLC

Percentage of Waste CLC as Agg (%)	Cement (kg)	Sand (kg)	Aggregates (kg)	Waste CLC as Agg Approx Kg	Water ml
0%	1.8	2.85	5.82	0	810
10%	1.8	2.85	5.238	0.582	810
15%	1.8	2.85	4.947	0.873	810

20%	1.8	2.85	4.656	1.164	810
25%	1.8	2.85	4.365	1.455	810
30%	1.8	2.85	4.074	1.746	810
35%	1.8	2.85	3.783	2.037	810

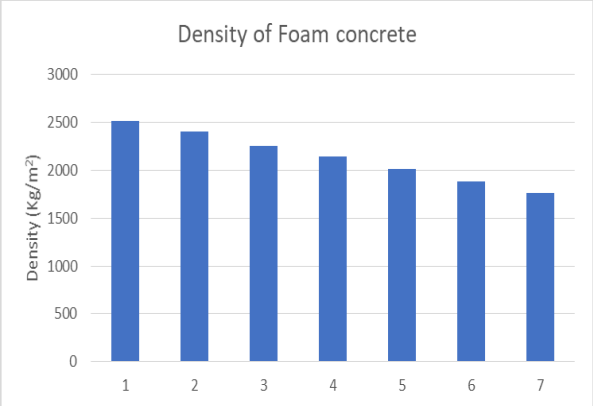
Fig 3 Curing and testing of cube

III. RESULTS OF ANALYSIS

A. Results for Density of Foam concrete

Table 3 Density of Foam concrete

Percentage Replacement	0%	0.25%	0.50%	0.75%	0.10%	1.25%	1.50%
M20 (Kg/m^2)	2515	2400	2255	2142	2012	1885.6	1759.2



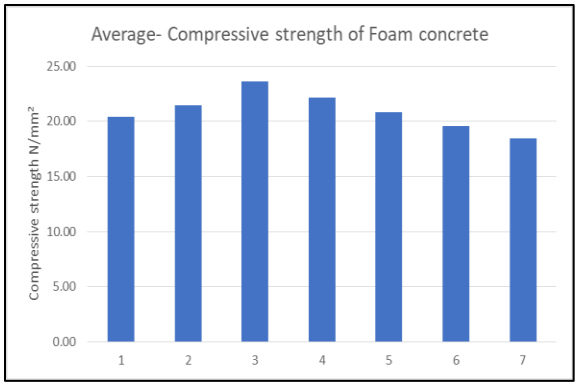
Graph 1 Density of Foam concrete

The density of Foam concrete decreases with the increase in percentage addition of foaming agent by 8-12%. Hence Foam concrete can be considered as light weight concrete which results in smaller dead loads. There is Need to check strength of the cube for better understand.

B. Compressive strength of Foam concrete

Table 4. Compressive strength of Foam concrete

Percentage Replacement	0%	0.25%	0.50%	0.75%	0.10%	1.25%	1.50%
Specimen 1	20.5	21.53	23.68	22.26	20.92	19.67	18.49
Specimen 2	20.09	21.96	24.15	21.81	21.34	20.06	18.12
Specimen 3	20.71	20.88	22.97	22.48	20.30	19.08	18.67
Average	20.43	21.46	23.60	22.19	20.85	19.60	18.43



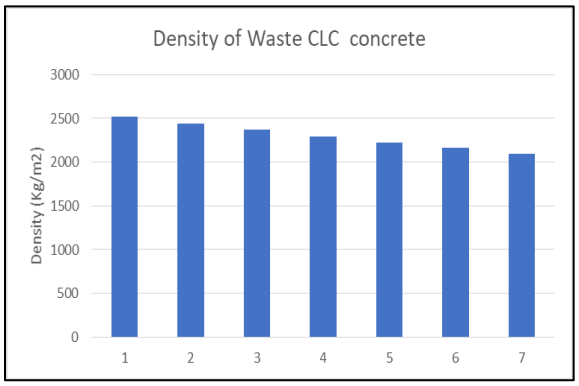
Graph 2 Average- Compressive strength of Foam concrete

The above graph represents the average compressive strength of foam concrete specimens at varying foam content percentages (0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.25%, and 1.5%). From the graph, it is observed that the compressive strength of foam concrete increases steadily up to 0.5% foam content. This indicates that the incorporation of foaming agent up to this level enhances the concrete's performance, likely due to improved workability and a more uniform distribution of fine air voids without compromising the structural integrity

C. Density of Waste CLC concrete

Table 5 Results for Density of Waste CLC concrete

Percentage Replacement	0%	10%	15%	20%	25%	30%	35%
M20 (Kg/m^2)	2515	2439.55	2366.36	2295.37	2226.51	2159.72	2094.92



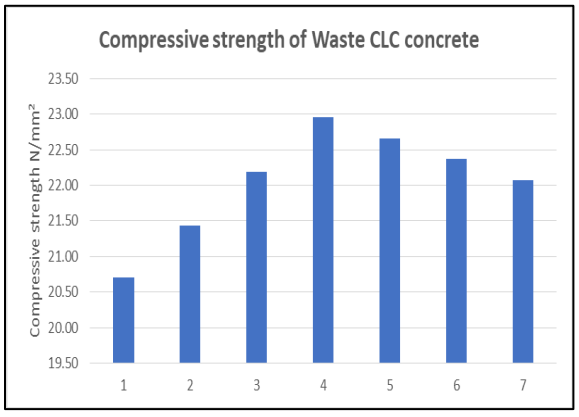
Graph 3 Density of Waste CLC concrete

The density of Waste CLC concrete decreases with the increase in percentage addition of Waste CLC by 5-6%. Hence Waste CLC concrete can be considered as light weight concrete which results in smaller dead loads. There is Need to check strength of the cube for better understand.

D. Compressive strength of Waste CLC concrete

Table 6 Compressive strength of Waste CLC concrete

Percentage Replacement	0%	10%	15%	20%	25%	30%	35%
M20 (N/mm²)	20.71	21.43	22.19	22.96	22.66	22.37	22.08



Graph 4 Compressive strength of Waste CLC concrete

The above graph illustrates the compressive strength of Waste CLC (Cellular Lightweight Concrete) concrete at different replacement levels: 0%, 10%, 15%, 20%, 25%, 30%, and 35%. From the data, it is evident that the compressive strength of Waste CLC concrete increases progressively up to 20% replacement, achieving its peak performance at this level

VI. CONCLUSION

- The experimental study on Lightweight Cellular Concrete (LCC) focused on evaluating the structural stability and compressive strength

characteristics of two types of LCC: foam concrete and Waste CLC concrete. Based on the analysis of test results, the following key conclusions are drawn:

- While both foam concrete and Waste CLC concrete provide the benefits of reduced density, Waste CLC concrete demonstrates better compressive strength and structural reliability.
- Waste CLC concrete offers a superior balance of strength, stability, and sustainability, making it more suitable for light structural applications.
- Foam concrete remains valuable for specific use cases, such as insulation layers, partition walls, and areas with minimal structural load.
- The compressive strength of foam concrete increases as the foam content rises up to 0.5%, indicating improved workability and internal structure. The optimum foam content for maintaining structural stability while achieving reduced density is identified as 0.5%.
- Lightweight Cellular Concrete can effectively replace conventional concrete in various applications where reduced weight, adequate strength, and sustainability are desired.
- Among the two, Waste CLC concrete is recommended for broader structural use, particularly when optimized at 20% replacement.
- Further studies are encouraged to explore durability, long-term performance, and cost-efficiency of LCC in real-world construction scenarios

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