High Strength Lightweight Foam Concrete

V Johnpaul\textsuperscript{1}, R Abiraami\textsuperscript{2}, R Sindhu\textsuperscript{3}, N Balasundaram\textsuperscript{4} and S. Solai Mathi\textsuperscript{5}

\textsuperscript{1,3,5}Assistant Professor, Department of Civil Engineering, Karpagam Academy of Higher Education, Coimbatore-21, Tamil Nadu, India.
\textsuperscript{2}Assistant Professor, Department of Civil Engineering, Christian College of Engineering and Technology, Oddanchatram, Tamil Nadu, India
\textsuperscript{4}Professor, Department of Civil Engineering, Karpagam Academy of Higher Education, Coimbatore-21, Tamil Nadu, India.

E-Mail: johnpaulv2490@gmail.com

Abstract. This research is to develop high strength lightweight foam concrete; Foam concrete is also called as lightweight concrete. Light Weight foam concrete enables in reducing the dead weight of the total Structure. The foaming agent used in this research is an Animal base, to create foam for foam concrete. The consistency of foam concrete should be equal to 1000kg/m\textsuperscript{3}. The compressive strength of the Light Weight Concrete varies from 6Mpa - 14Mpa. The main scope of the research is to increase the strength of the foam concrete by easily available sources. Foam concrete is an inventive applied science for viable construction in civil engineering applications. The property of foam concrete is to develop air bubbles with greater strength, stable during its manufacturing process by well mixing of ingredients, weathering condition on the site at the time of placing, and drying of concrete. The entire ratio is carried out only as trial mixes. The cube has been prepared for 7, 14, 28 days. Due to the presence of foam the cube should not be immersed in the water, only dry curing has been done. According to compressive strength result, the ratio which had the highest compressive strength can be used for both filling concrete and it can be used to create (Cellular Light Weight Concrete) CLC Blocks.

1. Introduction
Foam concrete is a combination of cementitious material with fly ash, water, foaming agent, gypsum, GGBS, quarry dust, and lime powder which is used as a foaming agent. It enables in heavy, reducing weight in the concrete of equally spread air bubbles at a constant rate. The unit weight of foam concrete is decided by its key factor ingredients. Foam concrete is developed by the homogeneous circulation of air bubbles entrapped in the whole density of concrete. Bubbles create a barrier inside the concrete which ensures a durable mixing, transmitting, draining, and deposition of a raw concrete mixture. Distinct particles of air bubbles range from 0.1 - 1mm. Foam concrete is a highly watery fluid and hence compaction need not be necessary. It is both fire and water-resistant. [1]experimented with foam concrete mixes with and without the addition of fine aggregate to confirm a higher density mix among them and compared with the normal weight concrete. [2]proposed a study on the incorporation of fly ash in various percentages and a different cement content weighed using expanded clay aggregate to achieve a high strength lightweight concrete. [3]recommended the usage of cellular lightweight concrete blocks in the construction industry. [4]discussed the transformation of aerated lightweight concrete into foamed and autoclaved concrete. [5]investigated the experimental work carried out on recycling the rice husk.
ash and fly ash in the concrete mixes. The results viewed to be worked better in physical and mechanical properties when compared to conventional concrete. [6] explained the practical job which was done by comparing the conventional clay bricks with cellular lightweight concrete blocks for computation of compressive strength between them at certain days of curing. [7] proposed a lightweight concrete using locally available lightweight materials and conducted an assessment in fresh and hardened nature. [8] experimented with the partial replacement of coarse aggregate with pumice and various cementitious materials were added in the mix to achieve a lightweight aggregate concrete and identified a strength increment with a reduction in weight at different trials. [9] described the evaluation of strength attainment was considerably greater in partial replacement of coarse aggregate using pumice stone when compared to conventional concrete. [10] carried out the quarry dust based foam concrete study on finding out the optimum dosage of foam thus minimizing the concrete weight. [11] described a lightweight aggregate concrete and limestone aggregate concrete were subjected to uniaxial tension through nitrogen gas pressure. Straining nature of lightweight concrete was moderately better than that of limestone aggregate concrete. [12] conducted an experimental investigation on foam polyethylene waste as proper utilization in lightweight concrete construction to prevent the coefficient of thermal expansion in concrete. [13] added an expanded polystyrene aggregate partially by the coarser one to ensure a lightweight concrete and further, these were tested to the basic properties study with suitable concrete density making lesser weight. [14] conducted a comparative survey on indoor radon concentration rate exhalation of lightweight concrete wall with a normal concrete wall and the results showed to be a less radon rate exhalation for the lightweight concrete wall when compared to normal concrete wall.

In this research, the effects of different mix proportions have been studied in detail on the compressive behavior of concrete using mineral admixtures at five mix ratios and comparative study has been made.

2. Experimental details

![Figure 1: Methodology of Proposed study](Image)

2.1 Materials

Foam concrete is in the form of a slurry of cementitious material, fine aggregate, water, fly ash, other materials, and foam generated by foam generating machine. Cement OPC 53, Lime Stone Powder, Fly Ash, Quarry Dust, Gypsum Powder, Foaming Agent, GGBS.

Cement OPC vanishes crack propagation and offer less heat of hydration thereby surface cracks get eliminated. PPC gives a uniform gradation in the concrete mix. It attains greater strength even after reaching 28 days. Better surface finish due to higher fineness. Ultra Tech Cement is used. It was purchased in SNA Steels, Malumichampatti. Limestone Powder which is fine is used. It is originated from sedimentary rock and composed of calcium carbonate-rich minerals including calcite and aragonite. It is purchased from Sethiya Solvents & Chemicals, Sukrawarpet, Coimbatore. Fly ash, also known as fuel debris which is meant to be a by-product of coal-generated from the thermal power station, mettur. Fuel debris production has been increased due to landfill cost and feasible utilization in the construction industry. It is a product obtained from the blasting of rocks. During this process, rocks get split into various sizes which are collected in the form of dust. In building construction, quarry dust can be used essentially as a source of fine aggregate. This promotes the economy in construction. It is bought from Ultra CLC Blocks, Veerapandi, Tirupur. It’s a good binding material which will help to bind all the material together and it will help the concrete to attain more strength by keeping all the materials bonded. The foaming agent is
derived from the animal protein. Foam is obtained by adding 1 liter of a foaming agent to the 40 liters of water. It is the formation of foam as a blowing agent. It increases its colloidal activity by hinder the fusion of bubbles and makes it stable. Foaming Agent is bought from CHRYSO. Ground Granulate Blast Furnace Slag is obtained by dampening fused thermal slag from a blast furnace in water or steam. Its obtained from the Thermal power station or steel manufacturing companies. It is bought from Mark Associates, Tiruppur.

2.2 Material test
The chemical composition (EDOX) test of various mineral admixtures like Gypsum, Dust, Lime, Flyash, are done in karunya institute of science and technology, Coimbatore, compared with cement and tabulated from Table 1 to 5 below.

Table 1. EDOX test on Gypsum

| Spectrum: Gypsum | Element | Series | Unn.C [wt. %] | Norm.C [wt.%] | Atom. C | Error (3 Sigma) [wt.%] |
|------------------|---------|--------|---------------|--------------|---------|-----------------------|
| Carbon           | K-series| 5.09   | 10.04         | 20.25        | 3.75    |
| Oxygen           |         | 12.03  | 23.74         | 35.95        | 6.51    |
| Aluminum         |         | 0.12   | 0.23          | 0.21         | 0.11    |
| Sulfur           |         | 12.46  | 24.58         | 18.57        | 1.43    |
| Calcium          |         | 20.97  | 41.40         | 25.02        | 1.93    |
| Total            |         | 50.66  | 100           | 100          |         |

Table 2. EDOX test on Dust

| Spectrum: Dust   | Element | Series | Unn.C [wt. %] | Norm.C [wt.%] | Atom. C | Error (3 Sigma) [wt.%] |
|------------------|---------|--------|---------------|--------------|---------|-----------------------|
| Carbon           | K-series| 3.12   | 15.83         | 25.85        | 1.86    |
| Oxygen           |         | 7.26   | 36.79         | 45.09        | 3.07    |
| sodium           |         | 0.34   | 1.73          | 1.48         | 0.15    |
| Aluminium        |         | 1.49   | 7.57          | 5.50         | 0.30    |
| Silicon          |         | 4.23   | 21.42         | 14.96        | 0.62    |
| Potassium        |         | 1.61   | 8.16          | 4.09         | 0.23    |
| Calcium          |         | 0.07   | 0.36          | 0.17         | 0.09    |
| Iron             |         | 1.61   | 8.14          | 2.86         | 0.22    |
| Total            |         | 19.73  | 100           | 100          |         |

Table 3. EDOX test on Lime

| Spectrum: LIME  | Element | Series | Unn.C [wt. %] | Norm.C [wt.%] | Atom. C | Error (3 Sigma) [wt.%] |
|-----------------|---------|--------|---------------|--------------|---------|-----------------------|
| Carbon          | K-series| 8.67   | 11.12         | 20.20        | 4.21    |
| Oxygen          |         | 29.86  | 38.28         | 52.19        | 13.16   |
| Magnesium       |         | 0.30   | 0.39          | 0.35         | 0.14    |
| Silicon         |         | 0.05   | 0.06          | 0.05         | 0.09    |
| Calcium         |         | 38.93  | 49.89         | 27.16        | 3.50    |
| Niobium         |         | 0.20   | 0.26          | 0.06         | 0.11    |
| Total           |         | 78.01  | 100           | 100          |         |
### Table 4. EDOX test on Quarry

| Element      | Series | Unn.C [wt.%] | Norm.C [wt.%] | Atom.C | Error (3 Sigma) [wt.%] |
|--------------|--------|--------------|---------------|--------|------------------------|
| Carbon       |        | 3.88         | 8.79          | 14.74  | 3.19                   |
| Oxygen       |        | 16.32        | 36.96         | 46.51  | 6.99                   |
| Sodium       |        | 0.10         | 0.24          | 0.21   | 0.11                   |
| Magnesium    | K-series | 0.09       | 0.21          | 0.17   | 0.10                   |
| Aluminium    |        | 11.77        | 26.66         | 19.90  | 1.78                   |
| Silicon      |        | 10.31        | 23.34         | 16.74  | 1.42                   |
| Potassium    |        | 0.31         | 0.71          | 0.36   | 0.12                   |
| Calcium      |        | 0.80         | 1.82          | 0.92   | 0.17                   |
| Iron         |        | 0.56         | 1.27          | 0.46   | 0.17                   |
| **Total**    |        | **44.15**    | **100**       | **100**|                        |

### Table 5. Cement Properties Test

| Sl.No | Characteristics                  | Requirements as per IS | Test results |
|-------|----------------------------------|------------------------|-------------|
| 3.    | Magnesium oxide (% MgO)          | 10                     | 3.44        |
| 4.    | Sulphur trioxide (% SO₃)         | 3                      | 1.32        |
| 5.    | Sulphide Sulphur (%S)            | 1.5                    | 0.20        |
| 6.    | Loss on ignition (%)             | 5                      | 0.50        |
| 7.    | Insoluble Residue(%)             | 4                      | 0.32        |
| 8.    | Chlorides (%)                    | 0.1                    | 0.010       |
| 9.    | Finess (M²/kg) (Min)             | 225                    | 379         |
| 10.   | Setting time                     |                        |            |
|       | Initial                          | 30                     | 180         |
|       | Final                            | 600                    | 255         |
| 11.   | Soundness                        |                        |            |
|       | Le chatelier (mm)                | 10                     | 1.0         |
|       | Autoclave (%)                    | 0.8                    | 0.03        |
| 12.   | Compressive Strength (Mpa)       | 33                     | 38          |

### 2.3 Mix proportions and preparation of samples

Mix design is done as per the, trial and error method by taking the properties of mineral admixture, fine aggregate, and cement. A total of five mixes has been prepared out of 5 ratios 4th one is the nominal mix, we usually do it in conventional concrete. The specimens have been cast of size 150*150*150mm.
Table 6. Different Mix Ratio

| Materials      | Ratio 1 | Ratio 2 | Ratio 3 | Ratio 4 | Ratio 5 |
|----------------|---------|---------|---------|---------|---------|
| Cement         | 1       | 1       | 1       | 1       | 1       |
| Sand           | 1.5     | 1.5     | 1.5     | 1.5     | 1.5     |
| Fly Ash        | 15      | 10      | 20      | 30      | 25      |
| Quarry dust    | 30      | 25      | 35      | 30      | 25      |
| Lime Stone     | 30      | 25      | 35      | -       | 25      |
| Gypsum         | 25      | 20      | 30      | -       | 25      |

3. Casting of Cubes

3.1 Material fineness
All the materials should be mixed evenly and no material should be in the size of the granular it will result in the differential settlement which will result in the strength of the concrete. A machine like a ball milling can be used to break all the granular particles. All the materials will be feed into the machine and the iron ball will be added equal to the weight to grind the materials into microparticles.

3.2 Mixing of concrete
All the materials are evenly mixed using concrete mixer and Foam is created separately with the pressurized air and it is mixed with materials after it has mixed. Mixing of concrete should be even and gentle vigorous mixing will result in breakage of bubbles.

3.3 Placement
As the workability of concrete is high there is no need for compaction, the flow of concrete is high so that the concrete should be placed before it starts to settle.

3.4 Curing
As the foam is presented in the concrete it should not be placed or immersed inside the water which will result in the weakening of concrete. The curing has been done for 7, 14, 28 days. The curing that has been followed is dry Curing as show in figure 2.

Figure 2. Picture showing casted specimen for curing
4. Result and discussions

With the idea of trial and error method, 5 Different mixes have been taken by referring different journals, in that the Mix 5 has obtained more strength while comparing all other Mix. The compressive strength of lightweight concrete differs from 3Mpa to 17Mpa. Strength attained is 12Mpa, on further development, it can be used in any type of structure. As the core idea has no reference we have only taken the Compressive Strength, on development all other types of tests can be taken like tensile strength, Young’s Modulus, etc…. This mix ratio without any further development can be used in the partition walls in the framed structure and it can be used to manufacture (Cellular Light Concrete) CLC Blocks. A comparison is shown in figure 3.

5. Conclusion

- Mix 5 has obtained more Compressive strength than all other Mix as clearing mentioned in figure 3.
- Foam (Lightweight) concrete tends to obtain strength even after curing and 28days when compared to conventional concrete.
- On developing the process this type of concrete can be used in the massive structures which reduces the overall self-weight of the structure.
- Obtained results are drawn in terms of graphical form and presented for better understanding and further scope of experimentation.

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