Experimental Work on Light Weight Foam Concrete

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ABSTRACT:

Concrete is a well-known substance that is commonly used in the building industry for a variety of tasks, from minor renovations to large-scale construction. Cement, water, and aggregate (coarse and fine) are the main ingredients in concrete, which also needs to be workable, inexpensive, resistant to chemicals, freezing, and wear. Lightweight foamed concrete was initially used in the unique precast use of autoclaved aerated concrete around a century ago; the documented applications were two seemingly unconnected projects in 1923, one in Denmark and the other in Sweden. As Portland cement and occasionally lime have been added to a slurry mix to make it alkaline, the entrained gases in this application are actually in that mixture.

KeyWords: Concrete, ingredients,

1.INTRODUCTION

Concrete occupies unique positions among modern construction materials. Cement and water are used to bind together hard, chemically inert aggregate to create the building material known as concrete. The material cost for prepared concrete is in high demand for construction purposes as compared to traditional concrete with comparable mechanical qualities. It consists of cementieous components and chemical admixtures such as shrinkage-reducing and viscosity-modifying substances. The method of choosing aim of producing appropriate concrete ingredients and determining their proportions with the concrete with the required strength, durability, and workability easily as possible.

Particularly, there are three categories into which lightweight concrete can be divided.

• No - Concrete with fines

• Concrete with lightweight aggregate.

• Concrete that has been aerated, foamed, or gas lightweight cellular concrete

1.1 Scope of The Activity

Foamed concrete is related to prior attempts to improve the mechanical properties of cement-based materials through reducing inhomogeneity, notably defined small particle (DSP) concretes. To achieve the greatest amount of self-compaction, FC is special in that it tries every grain size in the composite matrix.

The five main FC design principles are :

• Improvement of homogeneity through the removal of coarse aggregate.

• Improvement of density through granular mixture optimization and, if desired, pressure application before and during setting.

• Improvement of the microstructure through appropriate curing procedures.

• Better insulation thanks to the inclusion of air voids.

• Keeping mixing and casting processes as similar to current concrete industry practice as possible.

1.2 Material Selection

1.2.1 Cement

Cement is a finely ground substance with characteristics that act as a binding medium for the individual elements. Owing of the extremely high cement factor, FC performance may be significantly impacted by the cement used. 53 Grade Ordinary Portland Cement Complying with IS 12269 is a good option and complies with Indian Standard.

1.2.2 Fine Aggregate

Sand is the material with the largest particle in LFC. The silica (SiO_2)-containing sand particles are created when sandstones are deposited as a result of numerous weather-related factors. For practical reasons, the majority of sands can only be used to make foamed concrete with such a dry density above around 1200 kg/m3. Use of natural river sand that complies with IS 383 and matches the final product density In general, either natural or synthetic sand, or a combination of the two, must make up the fine aggregate.

1.2.3 Fly-Ash

The residue from the burning of pulverised coal that is removed from the gaseous products of thermal power plants by mechanical dust collectors, electrostatic precipitators, or separators is known as fly-ash or pulverised.

1.2.4 Water

Foamed concrete should only be made using drinkable water. Useful water has a pH of 6 to 8 and doesn't taste salty or brackish. Natural water which is only a little bit acidic is OK, but water that contains humic or other acids can compromise concrete's ability to harden.

1.2.5 Superplasticizer

Only because of the fluidizing capability of high quality 3rd generation super plasticizing substances are the extremely low w/c ratios utilised in LFC achievable. Without adding water, plasticizers aid in making concrete more workable. Using plasticizers allows for a lower water-cement ratio while maintaining the same cement content's workability.

Foam Concrete Vs Conventional Concrete

FC is made up entirely of fine aggregates. By stirring the air with a FA, the air pores are created. The average size of an air bubble is between 0.3 and 0.4 millimetres. Cement and water are the basic ingredients in cement grouting. When compared to regular concrete, FC is distinguished by its low cost and low density. FC has a density of between 400–1600 kg/m3. As a result, low density is advantageous for low dead loads and has a wide range of applications. Since FC doesn't call for compacting, it places no lateral stresses on nearby structures. Additionally, it has good water resistance and creates a lot of sound and heat insulation. Its only drawback is that it has a low compressive strength (less than 15 MPa), which sets it apart from traditional concrete and cement grouting.

REVIEW OF LITERATURE

2.1 Introduction

Several definitions exist for foamed concrete, which also goes by the names cellular concrete & foam concrete. Foamed concrete and similar materials, such as air-entrained concrete, were misunderstood in early literature. This distinguishes foamed concrete from (a) gas or aerated concrete, where the bubbles are chemically produced by the reaction of aluminium powder only with calcium & other alkalis released by cement hydration, & (b) air entrained concrete, which contains a significantly smaller amount of entrained air. Between 40% and 80% of the total volume. The material's 28-day compressive strength & dry density depending on its composition, mostly the amount of air spaces, but typically range from 1 to 10N/mm2 and 400 to 1600 Kg/m3, respectively.

2.2 Properties and Considerations

2.2.1 Thermal conductivity

Due to its cellular structure, foamed concrete has a poor thermal conductivity that is generally 5 to 30% lower than that of standard weight concrete. Normal weight concrete components would need to be 5 times thicker than foamed concrete components in order to obtain equal thermal insulation. Thermal conductivity of low density foamed concrete is as low as 0.32 Kcal/m/h/C; the lower the number, the greater the insulating characteristics. The range for typical weight concrete is 3.52 - 4.48 Kcal/m/h/c.

2.2.2 Fire and flame spread resistance

Foamed concrete has excellent fire resistance, and compared to regular concrete, it performs better at low temperatures in terms of proportional strength loss. However, it experiences excessive drying shrinkage at high temperatures. Foamed concrete is anticipated to be more flame spread resistant than standard weight concrete, even if this hasn't been studied in detail.

2.2.3 Embedment of services

As with well-compacted granular fill, similar measures should be provided for services cast inside foamed concrete. Re-excavating concrete that has been foamed makes it straightforward to reach services for upcoming repairs.

2.2.4 Risk of rodent attack

Since foamed concrete has a low strength, there may be a slight chance that rodents will attack it, especially if sewer pipes are embedded in it. Even though there haven't been any reports of such an incident, the problem may need to be addressed.

2.2.5 Rate of Hardening

The Initial and Final setting times of foamed concrete cannot be determined using a standard procedure. However, the techniques described In BS 4550:1978 and ASTM C266-89 for cement may serve as the foundation of appropriate techniques for foamed concrete with normal weight concrete. This is likely because of the foam's retarding properties. Foamed concrete typically takes between 12 and 24 hours to set.

Table 1: Properties of LFC as per IS 2185-2008

Dry Density, (kg/m3)	Compressive strength at 28 days (N/mm2)	Thermo conductivity (Kcal/m/h/0C)	Elasticity modulus (kN/mm2)	Dehydration Shrinkage (In Percentage)	Water Absorption (In Percentage)
800	2.5	0.32	2.0-2.5	0.20-0.22	12.5
1000	3.5	0.36	2.5-3.0	0.18-0.15	12.5
1200	6.5	0.38	3.5-4.0	0.09-0.11	10.0
1400	12	0.45	5-6	0.07-0.09	10.0
1600	17.5	0.50	10-12	0.06-0.07	7.5
1800	25	0.54	14-16.5	0.04-0.06	7.5

Table 2: Properties of LFC with fly ash as partial replacement

Mix	Plastic Density (in Kg/m^3)	Compressive strength at 28 days (N/mm2)		Tensile strength		Flow time* (in sec)	Plastic Viscosity* (Ns/m^2)
		NC	HC	NC	HC		
PC/SAND	1400	12	13.5	0.8	1.3	74	0.034
	1600	17.5	19.5	1.8	1.7	76	0.040
	1800	25	28.5	2.1	2.2	80	0.051
PC/PFA	1400	13.5	21.5	1.5	1.8	79	0.021
	1600	21.5	28.77	2.0	2.4	77	0.032
	1800	28.5	35.00	2.5	3.1	95	0.075

*Assessed using BRROKFIELD RVT viscometer

NC- Normal Curing, HC- Hot Curing

2.3 Application

Lightweight foamed concrete has various and expanding uses in all types of construction work. These are some of the most typical applications:

Table 3: Classification of application of LFC as per density.

Density (in Kg/m^3)	Application
300 to 600 (in Kg/m^3)	Thermo insulating block, steel constructions that are fire resistant, tunnels and pipelines that compensate for bulk, dumps, foundations, and coverings, as well as any sort of infill used to fill subterranean cavities where a high level of thermal insulation is necessary.
600 to 900 (in Kg/m^3)	Foundations for industrial buildings, ceiling slabs, pigsty and stable foundations, tamponing and partition slabs, and lightweight concrete mixed panels.
900 to 1200 (in Kg/m^3)	Panels made of a mixture of lightweight concrete and concrete are used to cover the elastic floor foundations. Outside wall blocks. A partition's slabs.
1200 to 1700 (in Kg/m^3)	Prefabricated panels are used to plug civil and industrial buildings and to cast garden ornaments into walls.

EXPERIMENTAL PROGRAM

3.1 Introduction

Concrete is the most often used material in building and is the second most utilised substance on earth after water. Cementing ingredients, water, aggregates, and admixtures in the proper quantities are mixed to create it. After being put into moulds & given time to cure, the slurry solidifies to become concrete, a substance that replicates rock. Due to the prolonged chemical interaction between water & cement that produces the hardening, concrete matures and gets stronger over time.

3.2 Preparation of Specimen

Cubes measuring 15 cm in size were used as the LFC specimens for compression experiments. All of the specimens were prepared for the test and put through the curing procedures at 210C. The specimen's ends were meticulously levelled to create flat, parallel surfaces. A cylindrical mould with sizes of 150 millimetres and 300 millimetres was used to create LFC specimens for stress tests.

3.3 Mixing of Concrete

The pre-foaming approach was used in this experiment. The first phase involved creating a base mix of concrete that included OPC, sand that mostly goes through a 2.0 mm sieve, and a little amount of water, while stable preformed aqueous foam was manufactured separately. In order to get the desired density, thoroughly integrate the foam into the base mixture. This blending is done using a revolving shaft attached to the tip of a particular drill bit on a hand drill that was used for each mix for at least 3 to 4 minutes. As a result, the foam and base mix particles are properly folded.

3.4 Batching

- It is recognised that PFA has a limiting effect on strength development and a decrease of hydration heat. In accordance with past experimental studies, PFA replaces between 28 and 30 percent of the substance of the binder..

● Dosage of super plasticizer is taken at 0.2% by weight of cement.

● Referring IS 9103:1999 air entertaining liquid admixture (foaming agent) is taken 3% of water content of base mix. A dilution ratio of 1:20 (FA:W) has been specified by the supplier.

● It is taken into consideration that PFA has a restraining impact on the growth of strength and the lowering of hydration heat. According to earlier experimental tests, between 28 and 30 percent of the binder's content is replaced with PFA.

Table- 4: Experimental Composition

Mix	Constituent	Plastic Density (kg/m^3)		
		1400	1600	1800
PC/Sand	Cement OPC 53 Grade (kg/m^3)	500	500	500
	Sand (kg/m^3)	7500	950	1150
	w/c+FA	0.30	0.30	0.30
	Water (ltr)	150	150	150
	Foaming agent (ltr)	4.5	4.5	4.5
PC/PFA/ SAND	Cement OPC 53 Grade (kg/m^3)	356	378	420
	Fly ash (kg/m^3)	144	160	180
	Sand (kg/m^3)	650	819	960
	w/c+FA	0.50	0.45	0.40
	Water (ltr)	250	243	240
	Foaming agent (ltr)	7.5	7.29	7.20

3.5 Preparation of Specimen

Cubes measuring 15 cm in size were used as the LFC specimens for compression experiments. All of the specimens were prepared for the test and put through the curing procedures at 210C. The specimen's ends were meticulously levelled to create flat, parallel surfaces. A cylindrical mould with sizes of 150 millimeters and 300 millimeters was used to create LFC specimens for stress tests. All the specimens were prepared for the test and put through the curing procedures at 210C. The specimens' ends were meticulously levelled to create flat, parallel surfaces.

3.6 Casting

The wet mixture was taken and placed into 150mm x 150mm x 150mm cube moulds and 150mm x 300mm cylinder moulds. As cellular concrete doesn't include coarse aggregate or the ball bearing effect of small foam bubbles, its fluid mass fills up level into moulds independently with no need for vibration or compaction. For 24 hours, the moulds are exposed to an open environment. The fly ash foam concrete requires an additional 4-5 hours to complete its hardening, whereas the typical foam concrete with sand can be demoulded after 24 hours of ambient environment exposure. The samples are then taken out of the mould and left to cure (7, 14, and 28 days).

3.7 Curing

The normal curing is done at atmospheric temperature in water up to 7 days, 14 days and 28 days from the date of casting.

RESULTS AND DISCUSSIONS

4.1 Introduction

To assess the impact of pulverized fuel ash and aggregate selection, w/b ratio, super plasticizer concentration, and curing regime, unique LFC compositions are created. The LFC mixes are created in order to measure various strength factors. The experimental work uses 150 mm cube moulds and 150 mm diameter x 300 mm length cylindrical moulds. The measurement of compressive strength is done during normal curing (NC) at 250C. Results for calculating compressive strength are produced after casting for 7, 14, and 28 days under normal curing regime conditions. Different mixes are prepared for the same proportion of ingredients varying the material quantities. Different designations are used for different composition of the mixes. These are denoted as LFC 1400, 1600 and 1800. The individual mix designs for these mixes and their various strengths are summarized. Graphs are plotted to show the comparison of strength at different age of loading. The quantity of materials are calculated based on the quantity of cement used in preparation of specimens to know the strength characteristics of LFC.

4.2 Observations and Results

The observations and result analysis of each individual mix of LFC specimens for determination of compressive strength, split tensile strength. The result analysis are made on the basis of the strength obtained at different days of normal curing. As per the plastic density for 7, 14, 28 days observations, 3 no of cubes has been prepared for each day. For each plastic density a total no of 9 cubes has been moulded for getting an average value of the cube strength and for cylinders the number of specimen is limited to 3 nos for each set. Each set is presented in table 4.1 consisting of 9 cubes. A total 54 nos of cube specimen for compressive strength determination and 27 no of cylinder specimen for splitting tensile strength determination has been made. The material calculations are made for different categories of the mixes and their result are shown by different curves and charts.

Table- 4: Quantity of Materials for 1 set of cube specimen for LFC Mix

Mix	Constituent	Plastic Density (kg/m^3)		
		1400	1600	1800
PC/ Sand	Cement OPC 53 Grade (kg/m^3)	15.18	15.18	15.18
	Sand (kg/m^3)	22.78	28.85	34.93
	w/c+FA	0.30	0.30	0.30
	Water (ltr)	4.55	4.55	4.55
	Foaming agent (ltr)	136	136	136
PC/ PFA /SAND	Cement OPC 53 Grade (kg/m^3)	10.81	11.48	12.75
	Fly ash (kg/m^3)	4.37	4.86	5.46
	Sand (kg/m^3)	19.74	24.87	29.16
	w/c + FA	0.50	0.45	0.40
	Water (ltr)	7.59	7.35	7.28
	Foaming agent (ltr)	227	220	218

4.3 Discussion on Results of Compressive Strength

In Table - 4.3 displays the findings of the LFC specimen's compressive strength after 7, 14, and 28 days with & without partial substitution by fly ash. The cube strength are calculated for the normal curing condition at 25^0C – 27^0C. The maximum strength is achieved in case of density of 1800 kg/m^3 in comparison to other mixes in both cases. From experimental observation in accordance with the literature reviews it is observed that, an optimum percentile i.e 28 – 30% of fly ash replacement haven't shown any significance variation in strength.

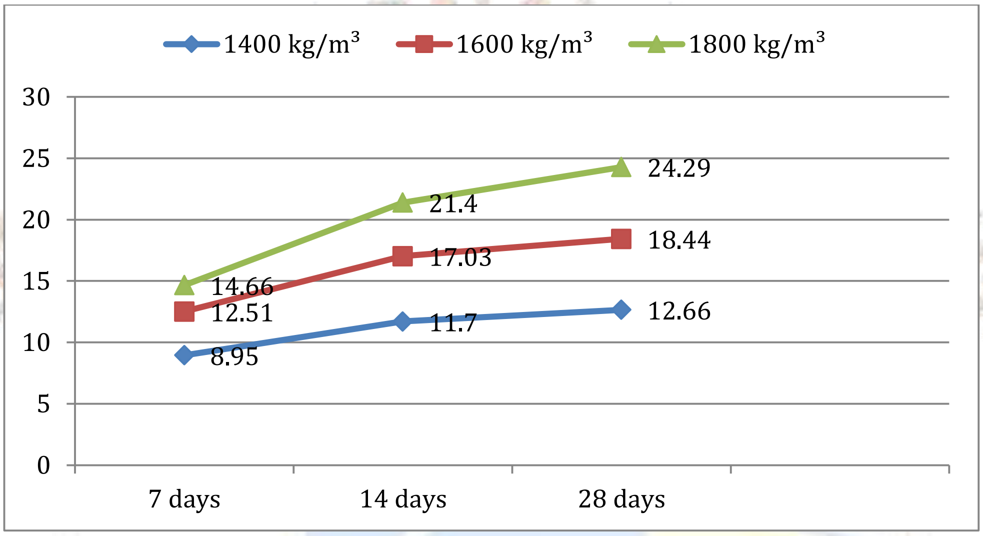

Figure -1 Compressive Strength of PC/SAND

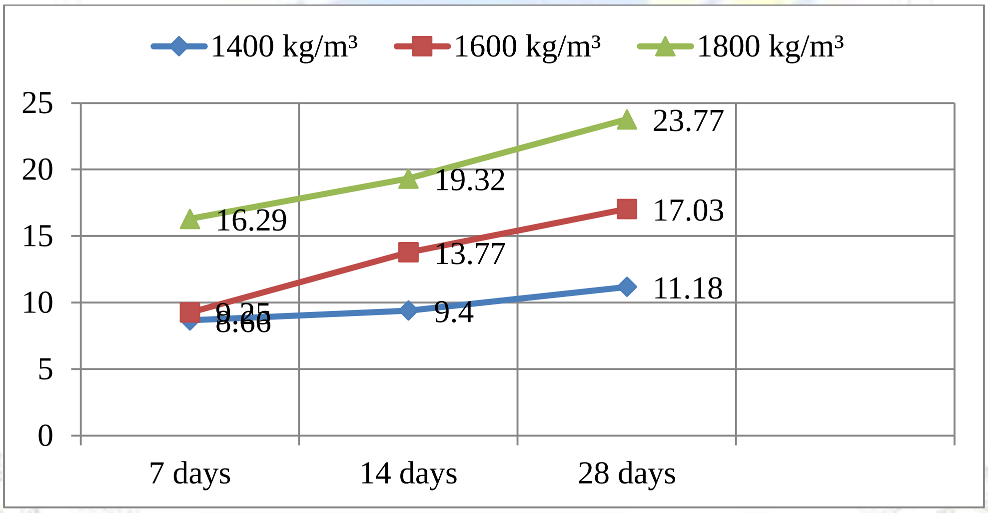

Figure-2 Compressive Strength of PC/SAND/PFA

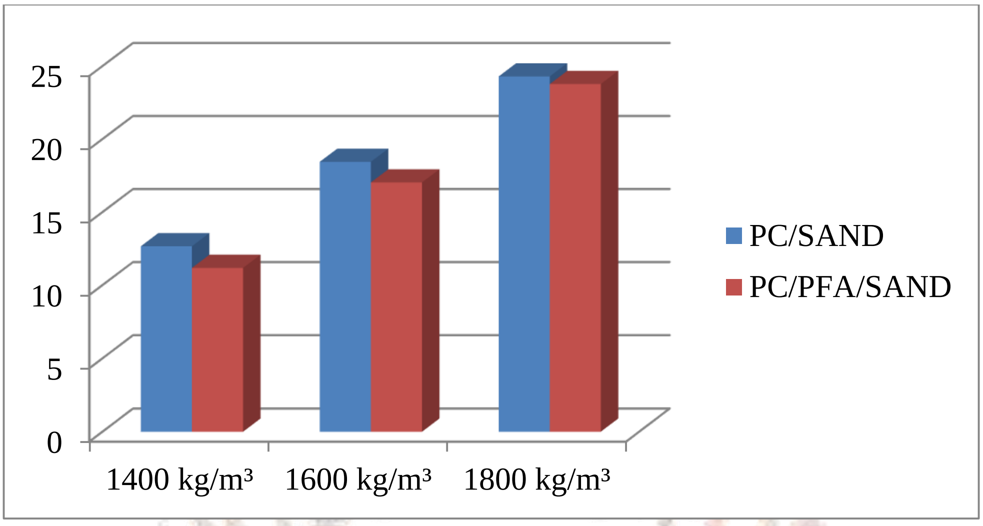

Figure-3 Comparison Between PC/SAND & PC/SAND/PFA

4.3.1 Result analysis for compressive strength of LFC mixes.

In Figure 4.1 for PC/SAND mix and Figure 2 for PC/PFA/SAND mix illustrate the LFC mix specimens' compressive strength for each of the three density considerations after 7, 14, and 28 days. The tests are performed for normal curing regime at 25^0C. A comparison between 28 days compressive strength between 28 days compressive strength between both mixes has been represented in fig.4.3. From the graphs it has been found out that, an optimum replacement of 28 – 30% of total binder content by fly ash gets no significant change in the physical as well as mechanical properties i.e compressive strength of LFC. Again in comparison, it is also found that a minimum variation of 3% and maximum variation of 12% in compressive strength is encountered for density of 1400 kg/m^3 respectively.

5. Conclusion

The amount of foam produces a variety of pore, void, and matrix structures that are associated with the production of microstructures. The investigational findings of this study show that because pores are created, the density of LFC impacts the mechanical properties. The pores created with simple density vary in terms of quantity and size. As more foam was added to the mixture, the low density of LFC caused more pores and voids. The density of 600 kg/m3 produced more pores of larger sizes than the density of 1000 kg/m3, as can be seen. More porosity or more air trapped are indicated by lower LFC density (larger pore size). Large pores are produced as a result of the pores combines together.

Future Scope

An technical innovation that gives the phrase "Lightweight Concrete" a new meaning is cellular lightweight foamed concrete. Because to its superior thermal and acoustic insulation, durability compared to traditional concrete, and capacity to produce low-rise structures with in situ walls, it has enormous promise in the construction industry. The innovation of LFC is based on the implementation of several key ideas in order to obtain enhanced homogeneity, excellent workability, self-compaction, superior micro structure, & high ductility. LFC has a less dense microstructure than other materials, which benefits its water resistance and durability properties. As a result, since it is recyclable, it might be an appropriate choice for research facilities, structures that require less dead load on it, and structures with short lifespans.

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