PROPERTIES OF CELLULAR LIGHT WEIGHT CONCRETE

S.Prabha[1], C.Chandrasekar[2]
[1]PG Scholar, ME Structural Engineering, [2]Assistant Professor in Civil Engineering,
Dr. Sivanthi Aditanar College of Engineering, Tiruchendur.

Abstract
Concrete is one of the popular and oldest materials widely used in construction project, therefore it has been used extensively in the field of infrastructure and construction since ancient days. One of the best types of concrete whose popularity increases rapidly now days are light weight foam concrete (LWFC). CLC (Cellular light weight concrete) is another light weight concrete material which are widely used in making infrastructure and high rise building. The main ingredients of making CLC is cement(OPC grade 53), Fly ash (class F),sand (passing 2mm sieve) , foaming agent(synthetic based foaming agent) used. The target density of Foam concrete in between 800-1600kg/m3. In this project 15% of cement is replaced by class F fly ash and the fine aggregate is replaced by RHA from 10% to 30% with the interval of 5%. To make light weight concrete synthetic based foams are added at constant of 1%.The water cement ratio is 0.6. The cement :sand ratio is 1:3. In this project foam is generated through open air mechanical stirring without using Foam generator. Then after, generated foam is now mixing into the cement slurry (cement, sand and fly ash,rice hush ash is used in making cement slurry) so that it attains a light weight concrete when became hardening. In this study, compressive strength, fresh density and dry density is evaluated and compared with the conventional concrete specimens.

Key words: Foaming agent; fresh density; dry density; compressive strength; density of cube.

1. Introduction

Light weight foamed concrete has become more popular in recent years owing to its tremendous advantages it offers over the conventional concrete. This chapter describes the nature of foamed concrete, its composition and properties and how it use in civil engineering works. Foamed concrete can be produced by introducing foaming agent. Concrete which is aerated using foaming agent is known as cellular light weight concrete.

1.1 Foaming agent

The containments holding foaming agent must be kept airtight and under temperatures not exceeding 250c. Once diluted in water the emulsion must be used soonest. Under no circumstances the foaming agent should not be brought in contact with any oil, fat, chemical or other material that might harm its function. (Oil has an influence on the surface tension of water). Foaming agents can be synthetic based or protein based.

1.2. Protein based foaming agent

Protein based foaming agents or hydrolyzed foaming agents are made by protein hydrolysis from animal proteins such as keratin (horn, meal and hoof), cattle hooves and fish scales, blood and saponin, and casein of cows, pigs and other remainders of animal carcasses. Their shelf life is one year under sealed conditions

1.3. Synthetic based foaming agent

Cellular light weight concrete has very good potential which helps to structure the cellular light weight applications. Using right category of foaming agent makes a huge difference in products such as the mechanical properties of concrete and its resistance etc. Synthetic foaming agents are such chemicals which reduce the surface tension of liquid and commonly used globally to make blocks, bricks, CLC concrete etc., where the high density is needed and it requires less energy for formation as compared to other foaming agents. It is highly recommended to use in the constructional field where requirement of light weight concrete is increasing by time.

1.4. Materials for cellular light weight concrete

The following materials can provide for cellular light weight concrete:

- Cement(OPC 53)
- Fine aggregate
- Water
- Foaming agent
- Rice hush ash

1.4.1. Cement

There are several type of cements available in market. Among which ordinary Portland cement is well known. 53 grade ordinary Portland cement conforming to IS 12269:1987 was used in this project.

1.4.2. Fine aggregate

Aggregate which passed through 4.75mm sieve and retained on 75 micron IS sieve is termed as fine aggregate. Fine aggregate is added to concrete to assist workability and to bring uniformity in mixture. Usually, the natural river sand is used as fine aggregate. Ordinary river sand conforming IS 383-1970 is used in this project.

1.4.3. Water

The water should be fit for mixing. The water should not have high concentrations of sodium and potassium and there is a danger of alkali aggregate reactions. Natural waters that are slightly acidic are harmless, but water containing humic or other organic acids may adversely affect the hardening of concrete. Such water as well as highly alkaline water should be tested. The water should conform to IS 456:2000 standards. Generally, water satisfactory for mixing is also suitable for curing purposes. However, it is essential that curing water should be free from substances that attack hardened concrete like free CO_2 etc. In this project locally available ground water is used.

1.4.4. Foaming agent

The containments holding foaming agent must be kept airtight and under temperatures not exceeding 250°c. Once diluted in water the emulsion must be used soonest. Under no circumstances the foaming agent should not be brought in contact with any oil, fat, chemical or other material that might harm its function. (Oil has an influence on the surface tension of water). Foaming agent we have used is synthetic based foaming agent.

1.4.5. Rice hush ash

Rice Hush Ash (RHA) is an agricultural by-product obtained from the process of burning rice husk under controlled temperatures below 800 °C. The by-product is black, grey, or pinkish-white, depending on the burning process. The burning process produces about 25% of ash containing 85% to 90% amorphous silica as well as about 5% alumina, which makes it highly pozzolanic.

2. Literature review

S.Azzarudin et al.(1999) discussed that the cellular lightweight concrete is lighter than the conventional concrete with a dry density of 300 kg/m3 up to 1840 kg/m3. It reduce the dead load and lower the haulage and handling costs. The materials used are ordinary Portland cement 53 grade, Fly ash class F obtained from thermal power plant, ordinary river sand and protein based foam. At the mixing stage start with water and fly ash and then mix cement and gradually add foam which is diluted in water. Curing can be ordinary water curing or steam curing. The author concludes that the weight of concrete cubes compared to conventional concrete is reduced to about 27.5% by weight. But at the same time there is no more reduction in strength. The strength is slightly lower than the conventional concrete.

P.S.Bhandariet al. (2000)explained that the main component of concrete is aggregate. In many areas large amount of aggregates that already been used means that local materials are no longer available. In this condition lightweight concrete is preferred. In this concrete pumice stone is used instead of aggregates. In mixing stage one part of cementious material (cement and fly ash) and 3 part of sand is used. This dry mix is mixed with water until homogenous mix is formed. While mixing 1% foaming agent is added to generate air voids. The author concludes that the compressive strength for cellular lightweight concrete is low for lower density mixture. The density increases strength also be increased. It is acceptable for framed structures and suitable for earthquake structures.

3. Scope and objective

The objective of the study is to

- To study the influence of Mechanical properties of foamed concrete.
- To determine the Density and Strength of foamed concrete.
- To study the Flexural Behaviour of foamed concrete with that of conventional concrete.

4. Experimental programme

The experimental programme was designed to find the optimum dosage of foaming by studying the mechanical characteristics of concrete such as compressive strength, Fresh density, Dry density. The details of number of specimens are shown in Table 1a

Table 1a: *Specimen description for cubes*

specimen	*Mix A*	*Mix B*	*Mix C*	*Mix D*	*Mix E*	*Mix F*	*Mix G*
Cube	*9*	*9*	*9*	*9*	*9*	*9*	*9*

Mix-A - 100% cement +100% fine aggregate + water + foaming agent-1%.

Mix-B - 85% cement +15% fly ash +100% fine aggregate +water +foaming agent-1%.

Mix-C - 85% cement +15% fly ash +90% fine aggregate +10% RHA +water +foaming agent-1%.

Mix-D - 85% cement +15% fly ash +85% fine aggregate +15% RHA +water +foaming agent-1%.

Mix-E - 85% cement +15% fly ash +80% fine aggregate +20% RHA +water +foaming agent-1%.

Mix-F - 85% cement +15% fly ash +75% fine aggregate +25% RHA +water +foaming agent-1%.

Mix-G - 85% cement +15% fly ash +70% fine aggregate +30% RHA +water +foaming agent-1%.

4.1. Quantity calculation

There is no standard mix proportion available for cellular light weight concrete. So we have to adopt the mix ratio 1:3. Water cement ratio is 0.6.

Table 4.1: Quantity calculation

Mix details	Cement (in m^3)	Fly ash (in m^3)	Fine aggregate (in m^3)	RHA (in m^3)	Water (in ml)	Foaming agent
MIX A	0.0015	0	0.00038	0	1230	21.4
MIX B	0.0015	0.000056	0.00038	0	1230	21.4
MIX C	0.0015	0.000056	0.00438	0.0001	1230	21.4
MIX D	0.0015	0.000056	0.00433	0.0002	1230	21.4
MIX E	0.0015	0.000056	0.00427	0.0002	1230	21.4
MIX F	0.0015	0.000056	0.00421	0.0003	1230	21.4
MIX G	0.0015	0.000056	0.00416	0.0003	1230	21.4

4.2. Testing

4.2.1 Fresh density test

A fresh concrete is filled in a 1 litre capacity container and kept in weighing machine. By slightly tapping at the sided of the container, compaction is done. Excess concrete is struck off and the container is wiped off .The weight thus obtained gives the fresh density of concrete.

4.2.2. Compressive strength: The cube specimens were tested on compression testing machine. The bearing surface of machine was wiped off clean and sand or other material removed from the surface of the specimen. The specimen was placed in machine in such a manner that the load was applied to opposite sides of the cubes as casted that is, not top and bottom. The axis of the specimen was carefully aligned at the centre of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. f_c = P/A , where, P is load and A is area.

4.2.3 Dry density

A Specimen after demoulded must be cured for 28 days in water.This cured specimen is kept in oven for drying at 110 degree Celsius for not less than 24 hours. The dry density of sample is calculated by

$$\text{Dry density} = \frac{\text{Dry mass of the specimen}}{\text{Volume of the specimen}}$$

5. Results and discussion

The result obtained from various tests such as fresh density, compressive strength and dry density were discussed and compared with conventional concrete.

5.1 Fresh Density

The values of fresh density of concrete for various mixes is shown in table 5.1.

Table 5.1 Fresh density test

Mix Details	Fresh density (Kg/m³)
MIX A	3148
MIX B	3010
MIX C	2994
MIX D	2966
MIX E	2927
MIX F	2862
MIX G	2824

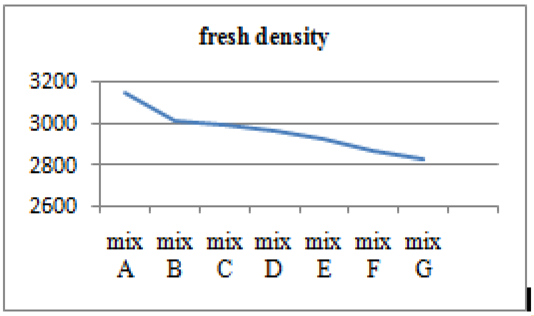

Fig 5.1 Fresh density

The fresh density values for Mix C, Mix D, Mix E, Mix F, and Mix G decreased when compared with both Mix A and Mix B. The decrease in density is due to the increase in percentage of rice husk ash in the foamed concrete, as the weight of rice husk ash is lesser than the fine aggregate.

5.2 Dry density

The values of dry density of concrete for various mixes is shown in table 5.2.

Table 5.2 Dry density test

Mix Details	Dry density (Kg/m³)
MIX A	1883
MIX B	1825
MIX C	1758
MIX D	1725
MIX E	1710
MIX F	1692
MIX G	1650

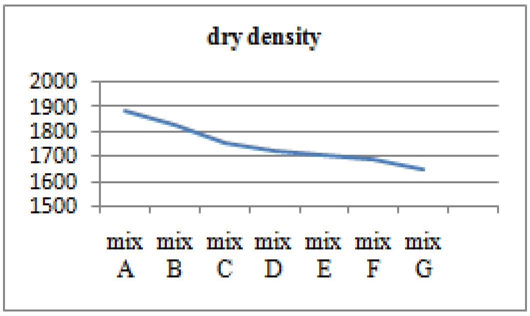

Figure 5.2 Dry density

The dry density values for Mix C, Mix D, Mix E, Mix F, and Mix G decreased when compared with both Mix A and Mix B. The decrease in density is due to the increase in percentage of rice husk ash in the foamed concrete, as the weight of rice husk ash is lesser than the fine aggregate.

5.3 COMPRESSIVE STRENGTH

The values of compressive strength of cubes at 7 days for various mixes is shown in table 5.3.

Table 5.3 compressive strength of cubes at 7 days

The variation of compressive strength of cubes at 7 days for various mixes is shown in figure 5.3.

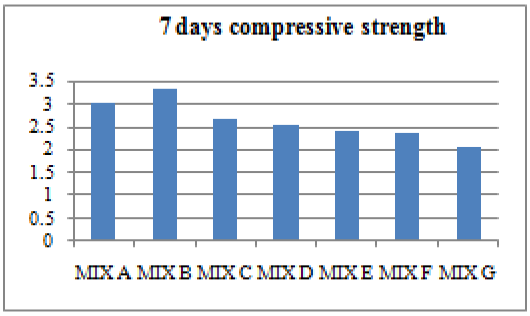

Figure5.3 compressive strength test at 7 days

The compressive strength at 7 days values for Mix C, Mix D, Mix E, Mix F, and Mix G decreased when compared with both Mix A and Mix B. The decrease in compressive strength is due to the increase in percentage of rice husk ash in the foamed concrete, as the weight of rice husk ash is lesser than the fine aggregate.

Mix Details	Average Compressive Strength in 7 days(Mpa)	Decrease In Compressive Strength (%) compared with	
		Mix-A	Mix-B
MIX A	3.01	-	-
MIX B	3.33	+10.63	-
MIX C	2.65	11.96	20.42
MIX D	2.55	15.28	23.42
MIX E	2.40	20.26	27.92
MIX F	2.35	21.92	29.42
MIX G	2.07	31.22	37.83

Table 5.3 compressive strength of cubes at 7 days

The values of compressive strength of cubes at 28 days for various mixes is shown in table 5.4

Mix Details	Average Compressive Strength in 28 days(Mpa)	Decrease In Compressive Strength (%) compared with	
		Mix-A	Mix-B
MIX A	4.08	-	-
MIX B	4.37	7.10	-
MIX C	3.83	6.12	12.35
MIX D	3.76	7.84	13.95
MIX E	3.62	11.27	17.16
MIX F	3.52	13.72	19.45
MIX G	3.35	17.89	23.34

Table 5.4 compressive strength of cubes at 28 days

The variation of compressive strength of cubes at 28 days for various mixes is shown in figure 5.4.

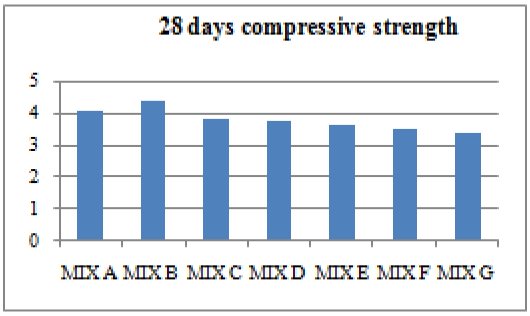

Figure 5.4 compressive strength test at 28 days

6. Conclusion

- The use of fly ash and rice hush ash in cellular light weight concrete and their effects had been thoroughly studied.
- The preliminary investigations were done for basic ingredients of cellular light weight concrete.
- From, the material property result, quantity calculation was arrived for plain cellular light weight concrete.
- For various mix, fresh density test, compressive strength and dry density test were conducted and result were discussed.
- The fresh and dry density test result shows that the density of concrete is decreased when compared to mix A and mix B.
- The compressive strength test results also decreased when compared to mix A and mix B.

7. References

1. Aswathy .M “Internal Experimental study on light weight foamed concrete”International Journal of Civil Engineering and Technology Volume 8, Issue 8, August 2017, pp. 1404–1412.
2. Ashish Kurweti, 2Ruchi Chandrakar., “Specification and Quality Control of Light Weight Foam Concrete ”, © 2017 IJEDR Volume 5, Issue 2 ISSN: 2321-9939.
3. A.Sattainathan Sharma S.SrisudharssanP.RathnaPriya., “Experimental Investigation on Cellular Lightweight Concrete” IJSRD - International Journal for Scientific Research & Development| Vol. 5, Issue 02, 2017.
4. A. Sattainathan Sharma, G. Suhil, L. Visali., “ Influence of Foam Densities in Cellular Lightweight Concrete”, (IJRASET) Volume 5 Issue IV, April 2017IC Value: 45.98 ISSN: 2321-9653.
5. Ashish S. Moon, Dr. Valsson Varghese , S. S. Waghmare., “ Foam Concrete as A Green Building Material” International Journal for research in emerging science and technology, volume-2,Issue 9, September 2015.
6. E. B Coker,*, S. Sadiku, J. I. Aguwa and M. Abdullahi., “Study of the strength characteristics of protein based light weight foamed concrete with cement partially replaced with rice hush ash” Nigerian journal of technology (NIJOTECH), volume-35, october 2016.
7. P.S.Bhandari1, Dr. K.M.Tajne,“Cellular Lightweight Concrete Using Fly Ash”, International Journal of Innovative Research in Science,Vol. 3, Issue 11, November 2014.
8. Raj Vardhan Singh Chande, Rashmi Sakale., “study of cellular light weight concrete” - International Journal for Scientific Research & Development| Vol. 4, Issue 07, 2016.
9. R H M Rum, Z M Jaini, K H Boon, S A AKhairuddin and N A Rahman., “foamed concrete containing rice hush ash as sand replacement” IOP Conf. Series:Materials Science and Engineering 271 (2017) 012012.
10. Trivedi Manoj S., Patel Harsh M., Chauhan Ritin k., “An experimental work on cellular light weight concrete” International Journal of Advance Engineering and Research Development Volume-02, Issue-03, March-2015.