EXPERIMENTAL STUDY ON FLY ASH BASED CELLULAR LIGHT WEIGHT CONCRETE USING M-SAND

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Abstract - *This project report deals with the experimental study of cellular lightweight concrete block which is used as a substitute for normal clay bricks. Nowadays, there are several alternates for bricks such as AAC blocks, hollow blocks and solid blocks, etc., but they consume high amount of cement and sand which are of great demand and rarely available rather than other construction materials. Hence, we have tried to produce an alternative material with reduced cement content using fly ash and M-sand. The technique of light weight concrete is known since the roman period. The light weight concrete has several advantages which are discussed in the project report. We have tried to produce CLC blocks with different proportions of cement and fly ash. Since there might be a scarcity for thermal plant fly ash or rise in price of fly ash in future due to the development of atomic power plant, we produced CLC blocks using m-sand by totally replacing fly ash. We conducted several tests such as compressive strength test, water absorption test and fire resistance test and computed the results in a plot to study the properties of the block and made several conclusions based the results. This report comprises of the test results and conclusion of our project work.*

Key Words: CLC blocks, Fly ash, M-Sand, AAC blocks, Clay bricks, Solid blocks..,

1. INTRODUCTION

Concrete is most important construction materials. Concrete is a material used in building construction, consisting of a hard 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 other civil works which has mitigate the raw material in concrete like aggregate.

In some rural 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. So a innovative way towards cellular lightweight concrete in civil engineering construction is used.

Lightweight concrete has tremendous weight to the construction industry. Nearly all present concrete study focuses on high-performance concrete, which is meant by a cost of effectual material so as to satisfy challenging performance necessities, as well as durability.

Lightweight concrete be able to define like a kind of concrete which include an increasing mediator in that it increase the amount of the mix while giving additional character such as narrowed the dead weight. It is lighter than the conventional concrete. The utilization of lightweight concrete has been extensively extended over the countries such as USA, United Kingdom and Sweden. The additional major specialty of lightweight concrete is its small density and thermal conductivity. So its benefits are that there is a lessening of dead load, earlier building rates in construction and lesser transport and usage expenses.

Cellular concrete, occasionally referred to as foam concrete, is a lightweight construction material consisting of Portland cement, water, foaming agent and compressed air.

The foam is formulated to provide stability, increase in volume of mortar and prevent draining of water.

2. TESTING OF RAW MATERIALS

2.1 Cement

The cement is used for built-up CLC block is ordinary Portland cement (OPC) which having 53 grade confirming to is 12269:1987. The specific gravity of cement which is required in CLC block is 3.5. The fineness of cement of 90 microns is up to 10% and the material is kept in temperature 27°±2°c.

2.2 Fineness test:

The fineness of cement is obtained using sieve analysis. 100 grams of sample is weighed and is sieved through 90 microns sieve and the residue on sieve plate is weighed and noted. From the two weights the fineness of cement is obtained.

$$\text{Fineness} = {}^{W2} \times 100$$

W1

Where,

W_1= weight of sample

W_2= weight of residue on sieve

2.3 Consistency test:

P = (w/c)×100

Where,

p= Consistency of cement (which ranges between 27-32 for OPC 53) w= quantity of water

c= quantity of cement

2.4 Water

The water which is required in the manufacture of CLC blocks is potable water and whose pH value lies between 6.5 to 8.5.the total dissolved solids tolerable is 0-300 mg/l. Moreover drinking water is perfect. The pH value is measured using pH meter.

2.5 Fly ash

The fly ash is collected from thermal power plant as a by-product. According to IS code 3812(part-1) fly ash is used. Optimum properties are achieved when selecting the most suitable raw material (fly ash, Cement). The fineness of fly ash is 20% fines. The density of fly ash is 888 kg/m^3.

2.6 Foam

The foam is produced using foam generator by passing compressed air over a solution of foaming agent dissolved in certain amount of water. The foam produced should be of weight 80g/l. The foaming agent used is vegetable protein based foaming agent. We collected protein based foaming agent from **SOFAM SPECIALITY CHEM** located at Ranipet, Vellore district. The physical property of the foaming agent is listed below, Physical properties:

1. Pinkish clear liquid
2. Moderate viscous liquid
3. Density @ 30 deg.c: 1.02-1.08
4. Chloride content: nil
5. Sulphate content: nil

2.7 M-Sand

Manufactured sand is a alternate of river for construction purpose sand formed from firm granite stone by crushing. The compressed sand is of cubical form with stranded edges, washed and graded to as a construction material. The granite powder is sieved using 1.18mm sieve plate in order to obtain fine powder. The granite powder is used as an alternate of fly ash since there might be a scarcity for fly ash in future due to growth of atomic power plant. We collected the granite powder from **SHRI EASWAR GRANITES** located at kandigai, kancheepuram district.

3. MIX PROPORTION

While coming to the concept of manufacturing the mix design is an important step which is required for achieving the target strength and other requirements of the material. The quantity of raw materials to be added and other aspects such as water/cement ratio etc., is calculated using the mix design. There are several norms and code books available for the calculation of mix design for conventional concrete mix but there is no such code books for mix design of Cellular lightweight concrete. The mix design or ratio for producing CLC block is obtained using trial and error mix procedure. In this project we produced CLC block on four different ratios. In that three ratios are based on the different proportions of fly ash and cement and the last ratio is based on proportion of cement and m-sand (granite powder). The following is proportion thus obtained for the manufacturing of CLC block is shown below for 1m^3.

Table -1: Mix Proportion with Fly Ash for 1m^3

% of fly ash	**Cement (kg)**	**Fly ash (kg)**	**Foam (litres)**	**Water (litres)**
65	280	520	1 litre of foaming agent diluted in 50 litres of water	260
70	240	560	1 litre of foaming agent diluted in 50 litres of water	300
75	200	600	1 litre of foaming agent diluted in 50 litres of water	270

Table -2: Mix Proportion with Granite Powder for 1m^3

% of m-sand	**Cement (kg)**	**m-sand (kg)**	**Foam (litres)**	**Water (litres)**
60	260	44 0	1 litre of foaming agent diluted in 50 litres of water	240

4. PRODUCTION PROCEDURE OF CLC BRICK

4.1 Preparation and mixing of foam

The foam is a very important element of cellular lightweight concrete so it is also known as as foam concrete. The foam is produced by using a vegetable protein based liquid compound. This compound is diluted in water at 20 ml/liters. This foam is put into specially designed machine for producing foam generally known as foam generator. The machine comprises of two units viz. pump for suction of diluted compound and air compressor for mixing air and producing foam.

There is a unit which mixes the compressed air with diluted compound at given pressure resulting in foam. The foam is thick and contains minute standardized shape bubbles. The bubbles in the foam do not disperse like soap bubbles but when mixed with the cement fly ash mixture it forms a homogenous mixture. The bubble in the foam gets trapped in the cement fly ash mixture making the brick light weight.

4.2 Charging and Mixing

Previous to charge the mixer with material, it must be rinse in exacting if the concrete formed before, use any additive, which might have unfavorable response on the foam. Where likely, begin the mixer before charging it with material. The material viz. cement and fly is placed in the mixing drum in calculated proportions and mixed by adding water, if the mixture is dry mixed the fly ash will disperse away as it is very fine. The mixture is of diverse type than normal concrete mixture. The mixer is charged with the raw materials and is washed after every batching, for the best results since the use of one material may affect the previous material that is used for the process of manufacturing

Fig -1: Mixer Drum

It has motionless external drum dissimilar the moving drum of concrete mixture, and internal coil which is rotating at 250-300 rpm. The helical operation is used instead of revolving entire drum so that the bubbles in the foam do not get dispersed. If the drum is used for mixing instead of helix the bubbles would get dispersed due to descending of material on each other

4.3 Placing/Pouring of CLC in the mould

The oiled mould is placed on clean surface preferably in shade avoiding direct sunlight. The ready foam is then pour gradually in the mould and at the same time the mould is shaken so that the material reach in each bend of the mould. The mould is full entirely and the further material top surface is stripy out and made plain. The mould is then reserved for 24 hours for setting of material. In between pours, the mixer should be kept in movement until it is totally discharged. CLC always should be poured in the shortest likely time. Use aluminum or other straight and sharp-edged screed slats immediately after pouring the CLC.

Fig -2: **Casting of Mould**

4.4 CURING &TRANSPORT

The block should be located upwards on the curing backyard, resting on a soft underground - best on a rake or wooden beams. All likely efforts should be taken, in particular in dry and hot climate or more even when windy, to keep the block damp for at least three, better for more days. It should be preferably kept in shade and in damp condition as the dry condition would absorb the moisture from the block reducing its strength.

A sprinkler will be helpful or gunny bag that is kept wet. Curing compound would be the costly alternative. Standards call for a 28 day curing period for cement-based blocks. Due to reduced weight, more volume of CLC more blocks can be transported at the same (increased pay-load) then of CC. Block should be kept upright during transport and also on a soft/wooden underground. Unload properly.

Fig -3: Curing and Placing of Blocks

5. RESULT AND DISCUSSION

Table -3: Dry Density Test for Fly Ash

% of fly ash	Sample no.	Mass (kg)	Volume of Sample (m^3)	Density (kg/m)	Avg. density (kg/m^3)
65	1	11.86	0.015	790	796.5
	2	11.67	0.015	778	
	3	12.32	0.015	821	
70	1	8.25	0.01	825	811.6
	2	8.18	0.01	818	
	3	7.92	0.01	792	
75	1	11.67	0.015	778	791.8
	2	11.92	0.015	794.6	
	3	12.05	0.015	803.3	

Table -4: Dry Density Test for Granite Powder

% of granite powder	Sample no.	Mass (kg)	Volume of sample (m^3)	Density (kg/m^3)	Avg. Density (kg/m^3)
60	1	10.01	0.015	667.3	670.8
	2	9.60	0.015	640	
	3	10.49	0.015	699.3	

Result:

1. The blocks produced using fly ash is of density = 800 kg/m^3 (avg.)
2. The blocks produced using granite powder is of density = 700 kg/m^3 (avg.)

Table -5: Compressive Strength Test for Fly Ash (7 Days)

% of fly ash	Sample no.	Load at failure (KN)	Area of loading (mm^2)	Compressive strength (N/mm^2)	Avg. Compressive strength (N/mm^2)
65 (6" block)	1	50	500×148	0.68	0.59
	2	30	497×150	0.40	
	3	50	500×148	0.68	
70 (4" block)	1	50	502×98	1.02	1.01
	2	40	497×100	0.80	
	3	60	500×98	1.22	
75 (6" block)	1	50	502×150	0.66	0.62
	2	40	498×152	0.53	
	3	40	500×148	0.68	

Table -6: Compressive Strength Test for Granite Powder (7 Days)

% of granite powder	Sample no.	Load at failure (KN)	Area of loading (mm^2)	Compressive strength (N/mm^2)	Avg. Compressive strength (N/mm^2)
60 (6"block)	1	60	498×148	0.81	0.71
	2	50	502×150	0.66	
	3	60	500×150	0.67	

Fig -4: Compressive Strength Test

Table -6: Compressive Strength Test for Fly Ash (14 Days)

% of fly ash	sample no.	Load at failure (KN)	Area of loading (mm²)	Compressive strength (N/mm²)	Avg Compressive strength (N/mm²)
65 (6" block)	1	30	148×152	1.33	1.33
	2	30	152×150	1.32	
	3	30	150×150	1.33	
70 (4" block)	1	50	152×148	2.22	1.92
	2	40	150×150	1.77	
	3	40	150×149	1.78	
75 (6" block)	1	30	152×148	1.33	1.04
	2	20	150×152	0.88	
	3	20	150×148	0.90	

Table -7: Compressive Strength Test for Granite Powder (14 Days)

%of granite powder	sample no.	Load at failure (KN)	Area of loading (mm²)	Compressive strength (N/mm²)	Avg. Compressive strength (N/mm²)
60 (6"block)	1	30	150×148	1.35	1.48
	2	30	152×150	1.32	
	3	40	150×150	1.78	

Table -8: Compressive Strength Test for Fly Ash (28 Days)

% of fly ash	sample no.	Load at failure (KN)	Area of loading (mm²)	Compressive strength (N/mm²)	Avg. Compressive strength (N/mm²)
65 (4"block)	1	40	150×102	2.61	2.64
	2	40	152×100	2.63	
	3	40	150×98	2.69	
70 (4"block)	1	50	148×102	3.31	3.10
	2	50	150×100	3.33	
	3	40	150×100	2.67	
75 (6"block)	1	40	150×148	1.80	2.07
	2	50	150×152	2.19	
	3	50	150×150	2.22	

Table -9: Compressive Strength Test for Granite Powder (28 Days)

% of granite powder	sample no.	Load at failure (KN)	Area of loading (mm²)	Compressive strength (N/mm²)	Avg. Compressive strength (N/mm²)
60 (6"block)	1	40	152×150	1.75	2.03
	2	50	153×150	2.17	
	3	50	150×152	2.19	

Based on the test results of various test performed in this project the graphical representation of the compressive strength of various ratios of CLC block is shown below for 7 days, 14 days and 28 days respectively.

Percentage of raw materials:

- 65%- fly ash & 35% cement
- 70%- fly ash & 30% cement
- 75%- fly ash & 25% cement
- 60%- granite powder & 40% cement

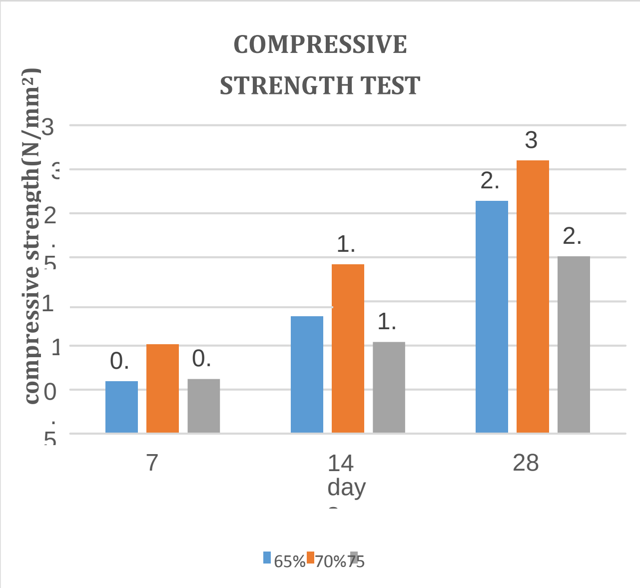

Chart -1: Compressive strength of CLC (fly ash)

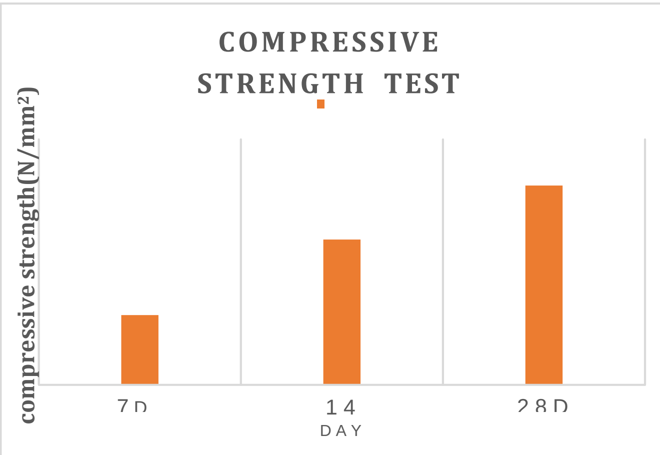

Chart -2: Compressive strength of CLC blocks (granite powder)

The above graphical chart represents the compressive strength readings of CLC blocks using m-sand at 7 days, 14 days and 28 days

Table -10: Water Absorption Test for Fly Ash

% of fly ash	Sample no.	Dry weight (kg)	Wet weight (kg)	Water absorption (%)	Avg. water absorption (%)
65	1	11.86	13.78	16.18	15.35
	2	11.67	13.57	16.28	
	3	12.32	14	13.6	
70	1	8.25	9.23	11.87	11.78
	2	8.18	9.1	11.23	
	3	7.92	8.89	12.24	
75	1	11.67	13.2	13.11	11.46
	2	11.92	13.13	10.15	
	3	12.05	13.39	11.12	

Table -11: Water Absorption Test for Granite Powder

% of granite powder	Sample no.	Dry weight (kg)	Wet weight (kg)	Water absorption (%)	Avg. water absorption (%)
60	1	10.01	10.82	8.09	8.5
	2	9.60	10.32	7.50	
	3	10.49	11.51	9.75	

5.1 FIRE RESISTANCE TEST

The air-embedded in the CLC is also influential for the high fire-rating. In 1200 kg/m^3 density a 13-14 cm thick wall has a fire endurance of 5 hours. The same delay occurs with a 400 kg/m^3 layer of CLC in only 10 cm thickness. CLC is otherwise non-combustible. In this project we passed the fire flame from gas welding cutter for just 20minutes on a 3cm thick sample of CLC block and the temperature is noted.

Fig -5: Fire Resistance Test

The above figure shows the fire resistance test in CLC block. The sample of 3cm thickness CLC block is subjected to 1500°c for 20minutes using gas welding cutter and the depth of penetration of heat is not even 1mm as shown in this figure 18. Therefore from the above test it can be said that CLC block is non-combustible and it can be used in construction of the buildings which has the risk of fire accidents.

6. CONCLUSIONS

Thus the various characteristics of the cellular light weight concrete blocks are tested and the results are obtained from which we can conclude that the use of CLC block as a replacement to normal bricks is advantageous. The compressive strength of the blocks obtained is also greater when compared to the normal bricks. The CLC is available in different density among which the density of 1800 kg/m^3 can be used in reinforcing structural elements. The use of polymers in CLC increases its tensile strength and makes it suitable replacement for concrete also. The advantages of the cellular lightweight concrete are discussed in detail in this project report.

The following table shows a comparative study between different types of bricks and proves that the use of cellular light weight concrete block is more economic and worth.

Moreover the CLC block has several great advantages such as fire resistance, thermal insulation, sound insulation and low water absorption capacity which makes them superior to normal bricks. The replacement of cement by 70%fly ash has showed best strength of 3.1 N/mm^2 than other ratios with a density of 800 kg/m^3. The replacement of fly ash totally with m-sand (i.e.) 60%-granite powder & 40%-cement also shows high strength of 2.03 N/mm^2 with density of 700 kg/m^3 when compared to 70% replacement of fly ash.

The use of CLC block is also found to be eco-friendly and cost effective since the use of cement is reduced. The reduction in quantity of cement reduces the cost of block and demand for cement there reducing the manufacturing of cement which turn reduces the amount of CO_2 emission into the environment caused from cement manufacturing industries and helps in reducing manufacturing process. The use of CLC blocks as a replacement of normal bricks also reduces the cost of construction as discussed above. Hence, this report concludes that the CLC blocks can be used as an effective alternative material for normal bricks. In future the development of atomic power plant causes the demand for thermal plant fly ash which is used as an replacement of cement in CLC block, hence in this project it has been proved that the use of m-sand (granite powder) instead of fly ash is also an cost effective process with each and every advantages of cellular lightweight concrete blocks.

Table -12: Comparison of Clay Bricks, Fly Ash Bricks and CLC Bricks

No	Parameters	Burnt Clay Bricks	Fly Ash Bricks	CLC Bricks
1	Basic Raw Material	Agricultural/ Red soil and wood,coal or Bagasse for firing	Cement, Fly ash, sand, aggregate	Cement, Fly ash, Foaming agent.
2	Production process	Process in brick kiln	Plant /project site	Plant/project site
3	Dry Density	1800-2000	900-2100	400-1800
4	Application	Load bearing and non-load bearing	Load bearing and non- load bearing	Thermal insulation, partition wall, non-load
5	Compressive strengthkg/cm2	20-80	30-150	25-40
6	Block size LxBxH mm	190x90x90 230 x 110 x 76 230 x 150 x 76	190x90x90 230 x 110 x 76 230 x 150 x 76	500x100x200 500x150x200 600x100x200
7	Warpage	<2.5 to 3.0 mm	< 1.0 to 2.0 mm	< 1.0 to 2.0 mm
8	Aging	No	Yes	Gains strength with age
9	Thermal Insulation	Better	Normal	Very good
10	Sound insulation	Normal	Better	Very good
11	Ease in working	Normal	Normal	Very easy
12	Labour requirement	100%	100%	50% brick work

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