EXPERIMENTAL STUDY ON LIGHT WEIGHT FOAM CONCRETE AS A REPLACEMENT TO CONVENTIONAL CLAY BRICKS

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ABSTRACT -The use oflight weight concrete is found to be advantageous in reducing the self-weight of any structure.Foam concrete is considered in the present study. Foam concrete is the one in which the total coarse aggregates can be replaced by introducing air voids with the help of a foaming agent. The density of foam concrete varies from 500 kg/m^3 - 1600 kg/m^3.The less density helps to reduce the dead load which results in economical structures in the field of construction.

In the present study, mixes of foam concrete varying cement to fly ash ratio as 1:0.5, 1:1, 1:1.5, 1:2 and each with and without sand are considered.For the eight different mixes, foam concrete blocks are prepared, cured for 28 days and tested for compressive strength, Water absorption and Density. Specific strength values are determined and compared with that of a conventional clay brick. Cost estimation of 1 m^3 of foam concrete is done. Reduction of dead load due to replacement of clay bricks with foam concrete blocks is discussed quantitatively.

Key words:Light weight concrete, Foam concrete, Compressive strength, Water absorption, Specific strength

1. INTRODUCTION

Concrete is one of the most broadly utilized construction materials in the world today. Therefore it is not surprising that much advancement in concrete technology has occurred. In concrete structures, self-weight is a major portion of the total load of the structure. Therefore in an attempt to reduce the dead load of the structure, the concept of light weight concrete has come into existence. Foam concrete is a type of porous concrete which reduces the density of concrete considerably. Foam concrete is a mixture of cement, sand, water, stable foam but no coarse aggregate. The foaming action incorporates small enclosed air bubbles within the mortar there by making the concrete lighter. Basically, there are two methods of producing foam concrete such as pre-foam method and inline method. Pre-foam method is used for the present experimental study. Foam concrete is described to have an air content of more than 25% which distinguishes it from highly air entrained materials. Density of foam concrete ranges from 500kg/m^3 to 1600kg/m^3 and Compressive strength from less than 1N/mm^2 to 25N/mm^2. The strength of foam concrete is affected by the cement content of the mix, cement to fly ash ratio, water to cement ratio, the proportion of cement to sand and the properties of the sand. High compressive strength is generally achieved with high cement content, a low water to cement ratio and use of sand in it. Foam concrete is a self-compacting concrete.

Fig. 1 Foam concrete

2. OBJECTIVES OF STUDY

a. To produce foam concrete with plastic density of 900kg/m^3 with tolerance of 50 kg/m^3.

b. To determine the compressive strength, water absorption and density of foam concrete blocks with and without sand for different cement to fly ash ratios.

c. Cost estimation for the production of 1 m^3 of foam concrete.

d. To decide whether the foam concrete blocks can replace the clay bricks effectively.

3. METHODOLOGY

Foam concrete is manufactured by introducing air voids into the cement based slurry. The slurry consists of cement, sand, fly ash and water. Fly ash is added as a cementitious material in a proportion with cement content. It also reduces heat of Fine sand is added according to the desired strength Depending on the required properties it can be produced with or without lightweight aggregate such as sand, fly ash. The introduction of air voids is achieved by adding pre-formed foam to the mixture. A foaming agent is diluted with water and aerated to form the foam.

4. RAW MATERIALS USED

Cement: Ordinary Portland cement of 53 grade confirming to IS 12269:2013 is used. The specific gravity of cement is 3.10. However, low grades of cement are suggested based on purpose of use if it demands low heat of hydration.

Fly ash: Fly-ash isa by-product of thermal plants. So, it is used as cement replacement to reduce the cost. Fly ash, enhance consistence of mix and to reduce heat of hydration while contributing towards long term strength. Fly-ash confirming to IS 3812 (Part-I):2003 is used.

Sand: Crushed sand, due to sharp edges may destroy the foam mechanically. So, locally available river bed sand is preferred. Zone-III sand confirming to IS 383:2002 is used. The quantity is selected in such a way to suit the target density of mix.

Water: The water used in the manufacture of concrete masonry units shall be free from matter harmful to concrete or reinforcement, or matter likely to cause efflorescence in the units and shall meet the requirements of IS 456.

Foaming agent: Foam is made from a concentrated foaming agent using a foam generator. In the foam generator the foaming agent is diluted in water to make a pre-foaming solution and then the pre-foaming solution is expanded with air into foam. The bubbles are stable and able to resist the physical and chemical forces imposed during mixing, placing and hardening of the foamed concrete. Between 75 and 85% of the bubbles are of 0.3 to 1.5 mm in diameter. Foaming agent used in this study is Sodium Lauryl Ether Sulphate.

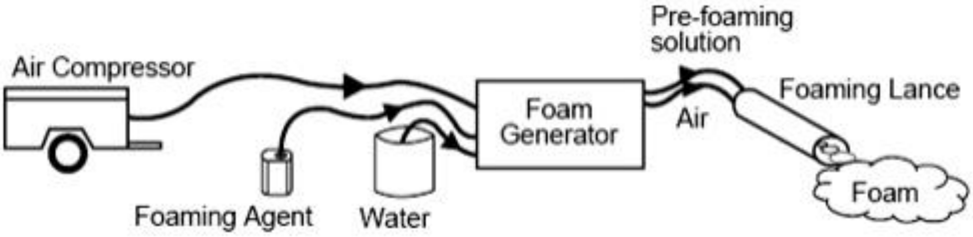


Fig.2 Making foam from foaming agent, water and compressed air

5. MIX PROPORTIONS AND TRIAL MIXES

The foam is produced by a foam generator in which a foam concentrate, usually diluted in the ratio of 1 part of concentrate to between 20 to 50 parts of water. This diluted amount is used for 500 liters of water. From this relation we can find the required amount of diluted foam for our water content.

For example:
Dilution = 1:34 (i.e., concentrate:water)
500 lit. → 35 lit. (For 500 litres of water, we need35 litres of foaming agent)

Accordingly the calculations can be made for each trial mix.There is no specific code of practice for the foam concrete. To attain a light weight concrete mix, important criterion is density. Hence, the proportions of various constituents for each trial mix are calculated for a target density of 900kg/m^3.

Eight foam concrete mixes with and without sand and changing cement to fly ash ratios as 1:0.5, 1:1.0, 1:1.5, 1:2.0 for a target plastic density of 900 kg/m^3 are considered in this investigation. Dilution of foam concentrate is taken as 1:34, which makes foaming agent : water as 1:35.Water to Cement ratio (w/c) is taken as 0.60. Mix calculations are done for 1 m^3 of concrete and are tabulated separately for mixes with and without sand.

Table 1: Trail mix containing 0% of sand for 1m^3

	Sand 0% of cement			
	W/C = 0.6			
	Foaming agent : water = 1:35			
Cement : fly ash	1:0.5	1:1	1:1.5	1:2
cement(kg)	420.5	341	286.5	247.3
Fly ash(kg)	210.25	341	429.75	494.6
sand(kg)	0	0	0	0
water(kg)	252.3	204.6	171.9	148.38
Foaming agent(kg)	17.661	14.322	12.033	10.3866
density(kg/m^3)	900.711	900.922	900.183	900.6666

Table 2: Trail mix containing 10% of sand for 1m^3

	Sand 10% of cement			
	W/C = 0.6			
	Foaming agent : water = 1:35			
Cement : fly ash	1:0.5	1:1	1:1.5	1:2
cement(kg)	401.5	328.5	277.8	240.7
Fly ash(kg)	200.75	328.5	416.7	481.4
sand(kg)	40.15	32.85	27.78	24.07
water(kg)	240.9	197.1	166.68	144.42
Foaming agent(kg)	16.863	13.797	11.6676	10.1094
density(kg/m^3)	900.163	900.747	900.6276	900.6994

6. RESULTS AND DISCUSSIONS

The results presented in this section are regarding the compressive strength test, density and water absorption for both mixtures of the foamed lightweight concrete. Eight foam concrete mixes with and without sand and changing cement to fly ash ratio for a target plastic density of 900 kg/m^3 are considered in this investigation.

Table 3: Compressive strength, water absorption and density test results

Sand content	**Cement : fly ash**	**Compressive strength (N/mm^2)**	**Water Absorption (%)**	**Density in oven dry condition (kg/m^3)**
0%	1:0.5	4.846	9.4	992.79
	1:1	4.403	8.2	955.43
	1:1.5	4.106	7.07	915.61
	1:2	3.816	5.2	876.98
10%	1:0.5	5.62	11.02	1030.30
	1:1	5.1	9.55	985.45
	1:1.5	4.523	7.99	946.34
	1:2	4.121	5.79	926.31

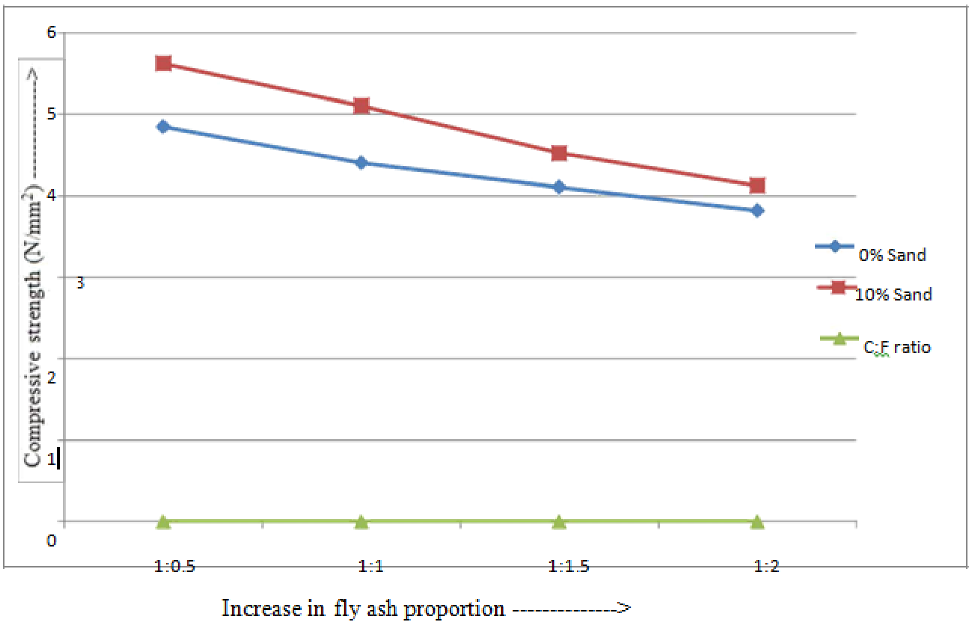
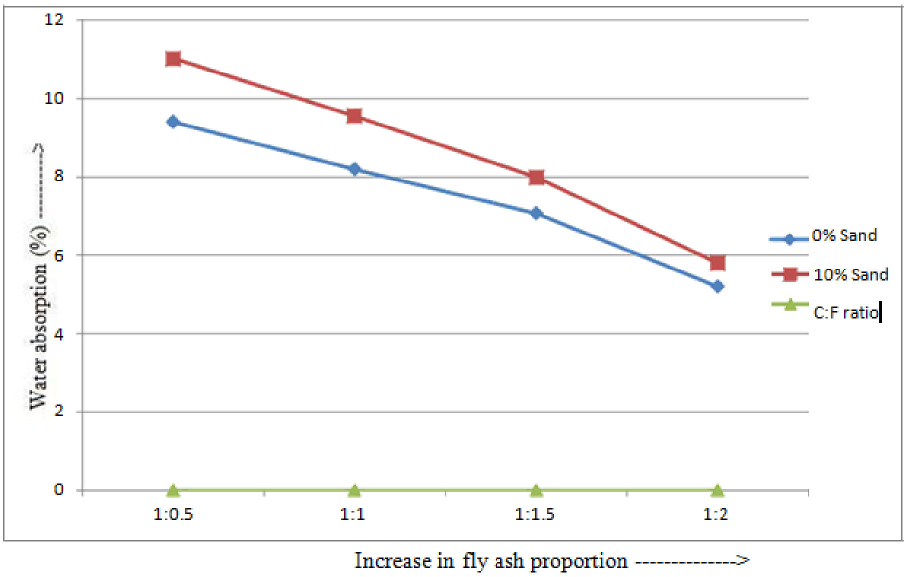


Fig. 3 Trend in Compressive strength with an increase in fly ash proportion



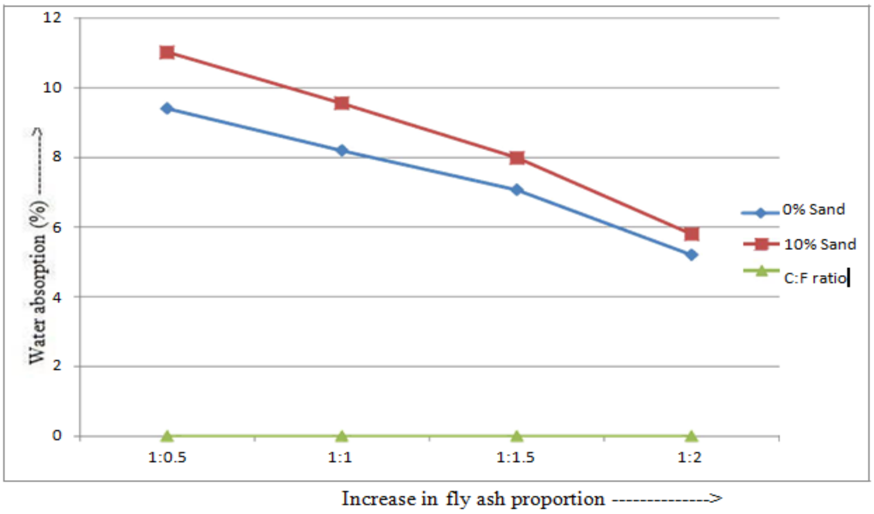


Fig. 4 Trend in Water absorption with an increase in fly ash proportion

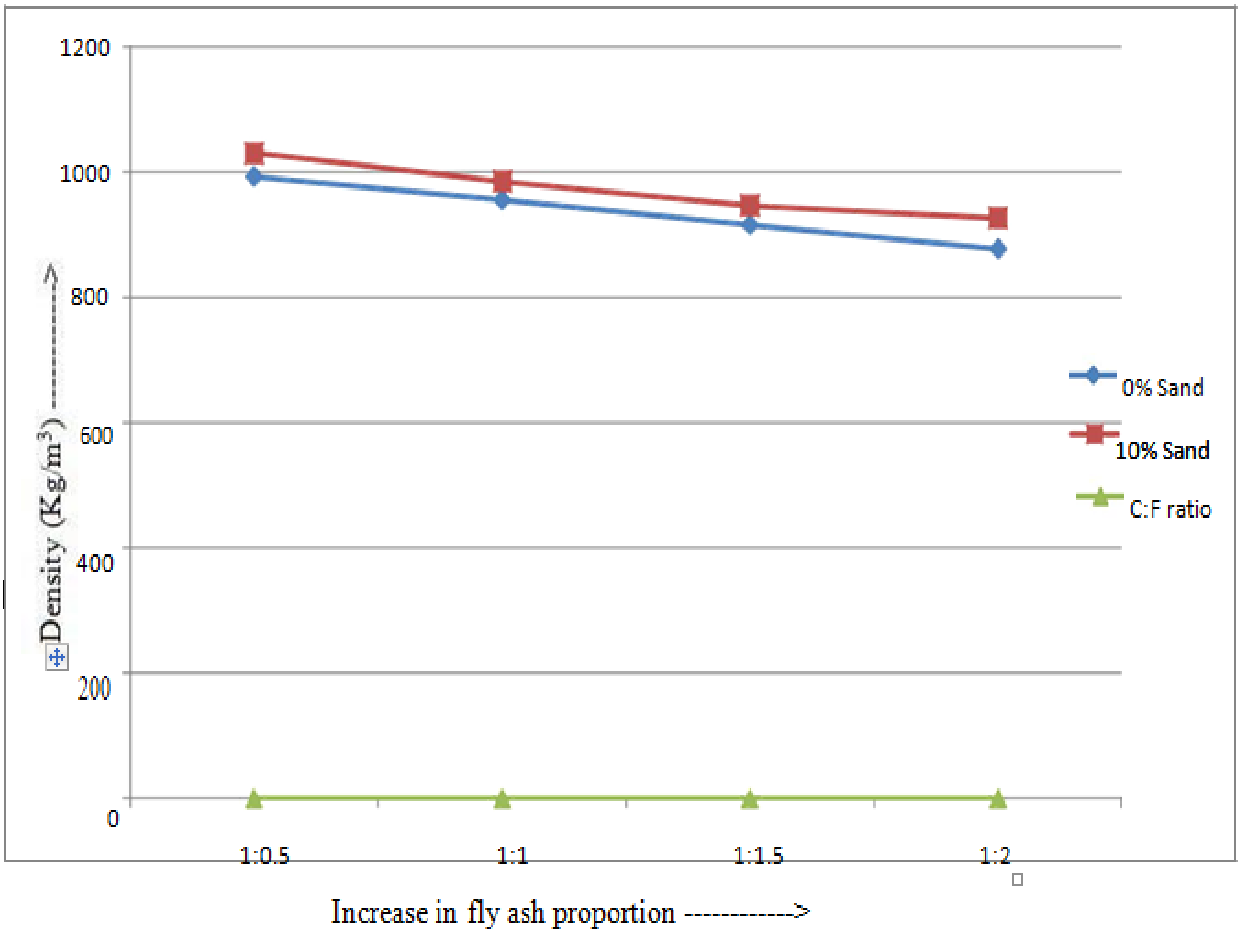


Fig. 5 Trend in Density with an increase in fly ash proportion

From the above results, it is understood thatthecompressivestrengthoffoamedconcrete decreases with increase in cement to fly ash ratio but increases with increase in sand content. The compressive strength decreased gradually from 4.8 MPa to 3.8 MPa varying cement to fly ash ratio from 1:0.5 to 1:2.0 without sand content in it. Also strength can be increased by an addition of 10% sand content to each of the fly ash proportion in the cementitious content. The strength values are for a density of 900 kg/m^3 which is very less compared to that of a conventional clay brick. In this context, a term called Specific Strength which is the ratio of strength to weight (or) strength to density can be considered. Specific strength values for each mix are tabulated below.

Table 4: Specific strength values for various mixes of foam concrete

Cement : Fly ash (% of sand)	Compressive Strength (N/mm^2)	Density (kg/m^3)	Specific Strength (N.m/kg)
1:0.5 (0% sand)	4.846	992.79	4881.2
1:1.0 (0% sand)	4.403	955.43	4608.4
1:1.5 (0% sand)	4.106	915.61	4484.4
1:2.0 (0% sand)	3.816	876.98	4351.3
1:0.5 (10% sand)	5.62	1030.30	5454.7
1:1.0 (10% sand)	5.1	985.45	5175.3
1:1.5 (10% sand)	4.523	946.34	4779.4
1:2.0 (10% sand)	4.121	924.31	4458.5

Specific strength values obtained for foam concrete mixes are as good as that of a conventional clay brick. The foam concrete blocks are not suggested for load bearing members based on the compressive strength results. However, they can be used for making partition walls in buildings which results in decrease in the self-weight of structure because the density is very low as compared to clay brick masonry work. Water absorption is considerably

7. COST ESTIMATION

Table 5: Cost estimate for 1 m^3 of foam concrete

Item	Qty.	Rate(Rs.)	Amount(Rs.)
Cement	240Kg.	6/Kg	1440
Fly Ash	481Kg.	1.5/Kg	721.50
Foaming Agent	1lit.	200/lit.	200
Labour	2 persons	200/day	400
Operating cost	-	-	250
	Total		3011.50

Size of one block : 150x150x550 mm

Volume of one block is 0.012375 m^3

Total number of blocks produced from 1 m^3 of concrete is

1/.012375 = 80.80 => 80 blocks

Cost of one block is 3011.5/80 = Rs. 37.65 => Rs. 38.00

The cost of a foam concrete block further reduces depending on the production scale in the industry

8. REDUCTION OF DEAD LOAD DUE TO REPLACEMENT OF CLAY BRICKS WITH FOAM CONCRETE BLOCKS

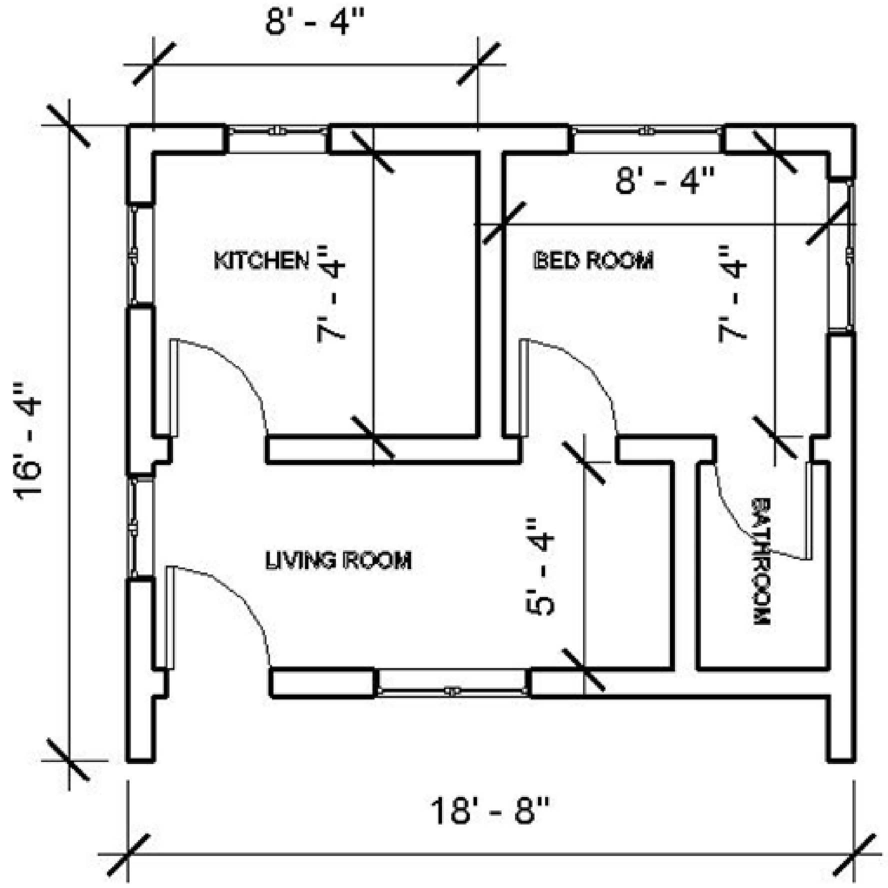


Fig. 6 Typical plan of a 1 BHK

Table 6: Calculation of total brick work

S.No.	Wall Type	Nos	Length	Breadth	Height	Total
1	Long wall-I	2	5m	0.230m	3.048m	7.01m^3
2	Long wall-II	1	5.73m	0.230m	3.048m	4.01m^3
3	Short wall-I	2	2.56m	0.230m	3.048m	1.79m^3
4	Short wall-II	2	2.25m	0.230m	3.048m	1.57m^3
5	Short wall-III	2	1.64m	0.230m	3.048m	1.149m^3
	TOTAL					15.52m^3
	Deduction for windows and Doors					3.5m^3
	Net Brick Work Area					**12.02m^3**

Total brick work in the building is 12.02 m^3

Unit weight of clay brick is 1900 kg/m^3
Unit weight of foam concrete block is 926 kg/m^3
Dead load due to clay brick wall is
1900x12.02 = 22,838 kg = 224 kN
Dead load due to foam concrete brick wall is 926x12.02 = 11,130.5 kg =110 kN

The dead load due to brick wall can be reduced by 50% using foam concrete blocks in the building construction and it further reduces the requirement of reinforcing steel to bear the dead load by significant amount.

9. CONCLUSIONS

The light weight foam concrete block is an excellent replacement for a conventional clay brick. Water absorption values are found to be low for a specific density as per IS 2185-4(2008). The minimum average compressive strength for a cellular concrete block of 3MPa as per IS: 2185-4(2008) is satisfied for the suggested mixes in the present study. The compressive strength of foam concrete decreases with an increase in the proportion of fly-ash in the total cementitious content. But the use of foam concrete blocks is recommended for the non-load bearing structural elements. Specific strength values of the foam concrete blocks are equivalent to clay bricks. Therefore, using cement to fly ash ratio 1:2 results in the economically best mix. Use of foam concrete blocks in building results in the reduction of the dead load by 50% as compared to the load due to brick wall and further reduces the requirement of steel making it more economical.

10. REFERENCES

1. K. Ramamurthy, E. K. K. Nambiar, and G. I. S. Ranjani, “A classification of studies on properties of foam concrete,” *Cement and Concrete Composites*, vol. 31, no. 6, pp. 388-396, 2009.
2. Krishna Bhavani Siram, “Cellular lightweight concrete blocks as a replacement of burnt clay bricks”, International journal of engineering and advanced technology, vol. 2, issue 2, ISSN:2249-8958, 2012
3. Maheshkumar H, “Experimental study on foam concrete”, International journal of civil, structural, environmental and infrastructure engineering research and development, Vol. 4, issue 1, ISSN(P): 2249-6866, 2014
4. IS 2185 (Part 4):2008-Concrete Masonry units-Specification, Part 4- Preformed foam cellular concrete blocks
5. IS 12269: 2013-Ordinary Portland Cement-53 grade specification
6. IS 456:2000-Plain and reinforced concrete-Code of Practice
7. Neville.A.M., Properties of concrete, 5th Edition
8. M.S.Shetty, Concrete Technology Theory & Practice, S.Chand & Co
9. IS 3812 (Part-I):2003-Pulverized fuel ash specification, Part 1-for use as pozzolana in cement, cement mortar and concrete
10. IS 383:2002-Specifications for coarse and fine aggregates from natural sources for concrete