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Experiment on Foam Concrete with Quarry Dust as Partial Replacement for Filler

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***Abstract*— Foam concrete is a type of lightweight concrete. It is non-load bearing structural element which has lower strength than conventional concrete. Foam concrete has been successfully used and it has gained popularity due to its lower density than conventional concrete. It is created by uniform distribution of air bubbles throughout the mass of concrete. Recently, most studies on foam concrete concern on the influence of filler type used in manufacturing foam concrete. The density of foamed concrete is a function of the volume of foam added to the slurry and the strength decreases with decreasing density.**

This study was conducted to determine the compressive strength of foam concrete by using quarry as partial sand replacement material. This report presents the feasibility of the usage of quarry dust as 10 %, 20 % and 30 % and 40% substitutes for sand in foam concrete. Mix design were developed for various densities of foam concrete and their replacements. Tests were conducted on cubes study the strength of concrete made of quarry dust and results were compared with the control foam concrete. It is found that the compressive strength of foam concrete made of quarry dust are nearly 40 % more than the control foam concrete.

Keywords*— Foam Concrete, Aerated concrete, Foaming agent, Bubbles.

I. INTRODUCTION

A) Background

Concrete can be categorized into two which are conventional concrete and lightweight concrete. Both concrete shows different properties and usage. Generally, conventional concrete has a density of about 2300 kg/m^3, while lightweight concrete has a density between 300 kg/m^3 and 1800 kg/m^3[1][12]. The modern types of concrete include cellular or aerated concrete which is light weight and durable, making it easy to be handled. Lightweight concrete is widely used for modern construction as it is mortar less and can be produced with different densities. Lightweight concrete also known as aerated, cellular lightweight concrete, or foam concrete. The first lightweight autoclaved aerated concrete factory was built in 1943 in Emmering, near Munich, Germany. The product is now made in a number of countries in Europe, Asia, South America and the Middle East. This study focuses on usage of quarry dust in Foam concrete. Foam concrete is classified as lightweight concrete because it contains no large aggregates but only fine aggregate like fine sand, cement, water and foam.

Foam concrete is widely used in construction field and quite popular for some application because of its light weight such as reduction of dead load, faster building rates in construction and lower haulage and handling costs. It also has several advantages because of its porous nature; it provides thermal insulation and considerable saving in materials. The important application of foam concrete includes structural elements, nonstructural partitions and thermal insulating materials. Manufacturers developed foam concretes of different densities to suit the requirements. The density of foam concrete ranges from 300-1800 kg/m^3[2] and these products were used in bridge abutment, void filling, roof insulation, road sub base, wall construction, tunneling etc.

Another material used in the formation of foam concrete is quarry dust as partial material replacement for fine aggregate. Quarry dust is classified as fine material obtained from the crushing process during quarrying activity at the quarry site. In this study, quarry dust will be studied as replacement material to sand as fine aggregate. Quarry dust has been use for different activities in the construction industry such as for road construction and manufacture of building materials such as lightweight aggregates, bricks, tiles and autoclave blocks.

B) Scope of project

In this experimental study, the effect of quarry dust in lightweight foam concrete in terms of compressive strength had been focused. Cubes with dimension of 150 x 150 x 150mm are being considered for this project. Sample with 0% (no quarry dust), 10%, 20%, 30%, 40% of quarry dust in replacement for sand mass were casted. Foam concrete with density ranging from 800 kg/m^3 to 1400 kg/m^3 were prepared with the help of developed mix-designs. All samples were cured in water curing. The cubical samples were used as specimens to determine the compressive strength at the age of 7, 14, and 28 days.

II. METHODOLOGY

The methodology followed to carry out the project work is shown below. As the result of literature study, there was little publicly available information regarding the properties of foamed concrete, particularly regarding mix design procedures [3]. Using that informations, the preliminary tests were undertaken to obtain the data for mix design formulation. After achieving a complete mix design

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procedure, trial mixes are prepared to check with the density achievement at site. Then possible replacements are studied and finalized. For desired density, the trail cubes were casted with and without replacement.

Tests will be done to find if the cubes that are cast match the desired density after the curing process. If the desired density is achieved, then compressive test will be done on the foam concrete cubes so as to adjudicate their load carrying capacity. Using the same density, replacement with quarry dust as replacement for fine aggregate, mix-designs are worked out and percentage of quarry dust that can be added before the bubbles break are found out.

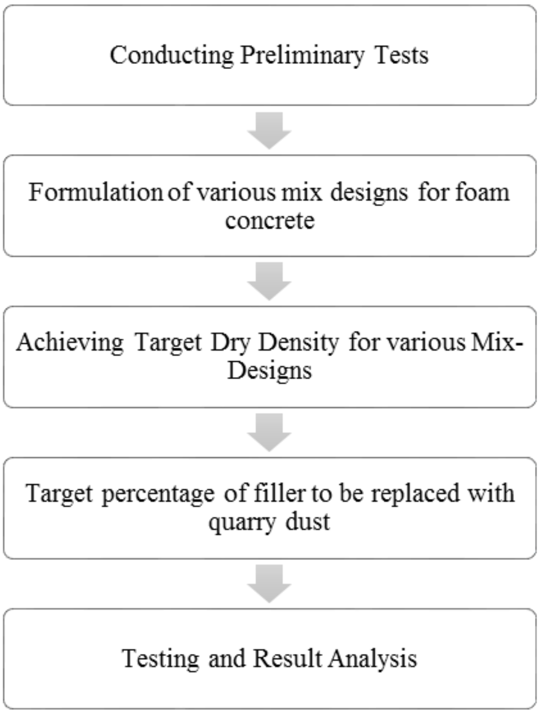

Fig. 1. Methodology

III. MIX DESIGN

The process of selecting suitable ingredients of concrete is termed as concrete mix design. The various materials used will be elaborated including the type of foaming agent and mix ration of foaming agent with water to produce stable foam.

A). Formulation of Mix Design

Since there are no standards for mix proportioning of foam concrete [6], this project is carried out with the formulation of the design procedure. Let W, C, S be the weight of water, cement, sand in kg/m^3 and Q be the Volume of foam in liters/m^3. The Possible parameters are chosen in such a way that it must have effect on compressive strength with basic scientific reason.

From the literatures we came to know that density is the primary factor to be considered. The compressive strength decreases exponentially with reduction in density of foam concrete [7]. The reason behind is that the other parameters like sand cement ratio and foam percentage has indirect effect on density of the mix. It is concluded that density should be used for mix designing [4]. So first stage of mix design is TARGET DENSITY rather than target mean strength in conventional concrete.

Weight based mix proportion is meaningless in proportioning materials for foam concrete, as hardened density varies by up to 10% depending on its free pore saturation level, it can be difficult to establish a true unit volume of foamed concrete [ASTM C796 / C796M.-12] .Thus foamed concrete is proportioned on a volume basis.
Assuming W/C and Sand/cement ratio, the cement content is obtained

Target density = cement content(C) + Water content (w) +Fine Aggregate (F)

To get the volume of foam:

V (m^3 of concrete) = V(foam) + V(cement) +v(sand)+v(water)

1 m^3 = V(foam) + Wc/(Sc x Dw) + Ww/(Sw x Dw) + Ws/(Ss x Dw)

Where,
Wc- Weight of cement
Ws- Weight of sand
Ww-Weight of water
Dw- Density of water
Sc- Specific gravity of cement
Sw- Specific gravity of water
Ss- Specific gravity of sand

The proportion of each materials to be added is obtained from two different companies for manufacture of foam concrete. The volume of foam is calculated using the above equations. Replacement such as 10%, 20%, 30% and 40% of sand with quarry dust is done.

TABLE I. MIX-DESIGN FOR CONTROL CUBES

DENSITY (kg/m^3)	CEMENT CONTENT (kg/m^3)	SAND CONTENT (kg/m^3)	FLYASH (kg/m^3)	WATER (kg/m^3)	FOAM VOLUME (kg/m^3)
800	250	150	400	100	575
1000	320	190	490	120	507
1400	400	800	0	200	373

Replacement of sand with quarry dust is done only for density of 1000 kg/m^3 and 1400 kg/m^3 because they have comparatively higher compressive strengths which will be shown in the later section

TABLE II. SAND REPLACEMENT FOR DENSITY OF 1000 kg/m^3

Sl No.	Replacement Percentage	Sand (kg/m^3)	Quarry Dust (kg/m^3)
1	10%	171	19
2	20%	152	38
3	30%	133	57
4	40%	114	76

TABLE III. SAND REPLACEMENT FOR DENSITY OF 1400 KG/M^3

Sl No.	Replacement Percentage	Sand (kg/m^3)	Quarry Dust (kg/m^3)
1	10%	720	80
2	20%	640	160
3	30%	560	240
4	40%	480	320

IV. EXPERIMENTAL INVESTIGATION

In this chapter, discussion will be focused on the performance of foam concrete with different percentages of quarry dust as filler replacement. All the tests method adopted were done according to IS standards as well as ASTM procedures. The results presented in this chapter are regarding the various preliminary tests done to various materials used as well as the compressive strength test for different replacement ratios of quarry dust as filler in the foam concrete.

A) Properties of Materials Used

The materials used for the present experimental work is discussed in the subsequent sections.

1) Cement

Ordinary Portland Cement (OPC) of 53 grade conforming to IS12269: (1987) is used and its properties are given in Table 4.1

TABLE IV. PROPERTIES OF CEMENT

S. NO.	**PROPERTY**	**EXPERIMENTAL RESULTS**	**LIMITING VALUES AS PER CODE (IS 12269 : 1987)**
1.	Fineness (Air permeability)	2465 cm^2/gm	Not less than 225 m^2/Kg
2.	Specific gravity	3.15	3.10 – 3.25
3.	Standard Consistency	33%	26 % - 35%
4.	Initial Setting time Minutes	48 Minutes	Not less than 30 minutes
5.	Compressive Strength at 28 days (N/mm^2)	55	Not less than 53 N/mm^2

2) Filler (sand)

Clean sand conforming to IS 383 :(1970) is used and its preliminary value is as shown below.

TABLE V. PROPERTIES OF SAND

Sl No.	Properties	Values	Standard values
1	Specific Gravity	2.74	2.6-2.85
2	Fineness	2.71	2-4

3) Water

Potable water available at site passing through IS 456 standards is used for mixing and curing

4) Quarry Dust

Quarry dust for the project was procured from nearby private civil Works with following specification

Specific Gravity= 2.72
Fineness Modulus=2.35
Bulk Density=1750 kg/m^3
Effective Size=0.22 mm

5) Fly-Ash

Fly ash used for this project is class-F fly ash obtained from the industrial are of Puzhal in Chennai.

Specific Gravity= 2.62
Bulk Density=2.62 g/cc

6) Foaming Agent

The foaming agent is the key agent in determining the stability of foam produced which is to be mixed in Foam concrete. Foaming agents are formulated to produce stable air bubbles which can resist the physical and chemical forces imposed during mixing, placing and hardening in the process of making foamed concrete. The foaming agent solution consists of one part foaming agent and between 30 to 60 parts water.

In this project both synthetic foaming agent and protein based foaming agent is used. The synthetic foaming agent was provided by Tom Engineers based in Chennai and the Protein based foaming agent was provided by Sathya foams also based in Chennai.

B) Compressive Strength of Cubes

Firstly control cubes of three densities were casted. Foam concrete of density 800 kg/m^3, 1000 kg/m^3 and 1400 kg/m^3. For density of 1400 kg/m^3 protein based foaming agent was used. Next the filler (sand) was replaced with required amounts of Quarry dust.

TABLE VI. COMPRESIVE STRENGTH OF CONTROL CUBES

SL NO.	DENSITY OF FOAM CONCRETE	SPECIMEN	COMPRESSIVE STRENGTH (N/mm^2)		
			7 DAYS	14 DAYS	28 DAYS
1	800 kg/m^3	1	0.571	1.23	2.48
		2	0.619	1.3	2.57
		Average	0.595	1.265	2.525
2	1000 kg/m^3	1	0.761	1.6	3.28
		2	0.857	1.73	3.42
		Average	0.809	4.62	3.35
3	1400 kg/m^3	1	2.53	4.88	8.22
		2	2.44	4.44	7.9
		Average	2.485	4.62	8.06

TABLE VII. 10 % REPLACEMENT OF SAND

SL NO.	DENSITY OF FOAM CONCRETE	SPECIMEN	COMPRESSIVE STRENGTH (N/mm^2)		
			7 DAYS	14 DAYS	28 DAYS
1	1000 kg/m^3	1	0.755	1.46	2.88
		2	0.711	1.37	2.93
		3	0.84	1.55	3.1
		Average	0.768	1.46	2.97
2	1400 kg/m^3	1	2.22	4.88	8.6
		2	2.4	5.06	8.4
		3	2.35	5.11	8.2
		Average	2.32	5.01	8.4

TABLE VIII. 20% REPLACEMENT OF SAND

SL NO.	DENSITY OF FOAM CONCRETE	SPECIMEN	COMPRESSIVE STRENGTH (N/mm^2)		
			7 DAYS	14 DAYS	28 DAYS
1	1000 kg/m^3	1	0.711	1.68	3.28
		2	0.8	1.6	3.46
		3	0.8	1.6	3.46
		Average	0.73	1.62	3.4
2	1400 kg/m^3	1	2.4	5.1	8.6
		2	2.75	5.24	8.88
		3	2.66	5.02	8.44
		Average	2.6	5.12	8.64

TABLE IX. 30% REPLACEMENT OF SAND

SL NO.	DENSITY OF FOAM CONCRETE	SPECIMEN	COMPRESSIVE STRENGTH (N/mm^2)		
			7 DAYS	14 DAYS	28 DAYS
1	1000 kg/m^3	1	0.755	2.04	4.16
		2	0.66	1.86	4.08
		3	0.8	2	4.20
		Average	0.738	1.96	4.16
2	1400 kg/m^3	1	2.88	5.77	10.22
		2	3.24	5.55	9.7
		3	3.11	5.33	9.55
		Average	3.07	5.55	9.82

TABLE X. 40% REPLACEMENT OF SAND

SL NO.	DENSITY OF FOAM CONCRETE	SPECIMEN	COMPRESSIVE STRENGTH		
			7 DAYS	14 DAYS	28 DAYS
1	1000 kg/m^3	1	0.66	1.77	3.6
		2	0.62	1.55	3.7
		3	0.66	1.77	3.77
		Average	0.646	1.51	3.69
2	1400 kg/m^3	1	2.66	4.66	7.77
		2	2.44	4.53	7.55
		3	2.44	4.22	8.08
		Average	2.51	4.471	7.8

V. RESULTS ANALYSIS

In this chapter presents the data analysis and discussions based on the compressive strengths obtained and presented in the tables above. The collected data were analyzed by plotting various graphs comparing the strengths taken at interval of 7days, 14 days and 28 days.

From the graph on the right we can infer that the compressive strength of foam concrete is directly proportional to the density of foam concrete produced. The density of foam concrete is the function of volume of foam that is added to the cement paste [7]. The compressive strength of foamed concrete is an inverse function of the density of the material. As in the case of foam concrete with density of 1400 kg/m^3, the foaming agent used is a protein based foaming agent. Hence we can infer that foam produced by protein based foaming agent is more stable than foam produced by synthetic foaming agents. This is due to the fact that foams formed from protein based foaming agent have smaller bubble size and hence more stable.

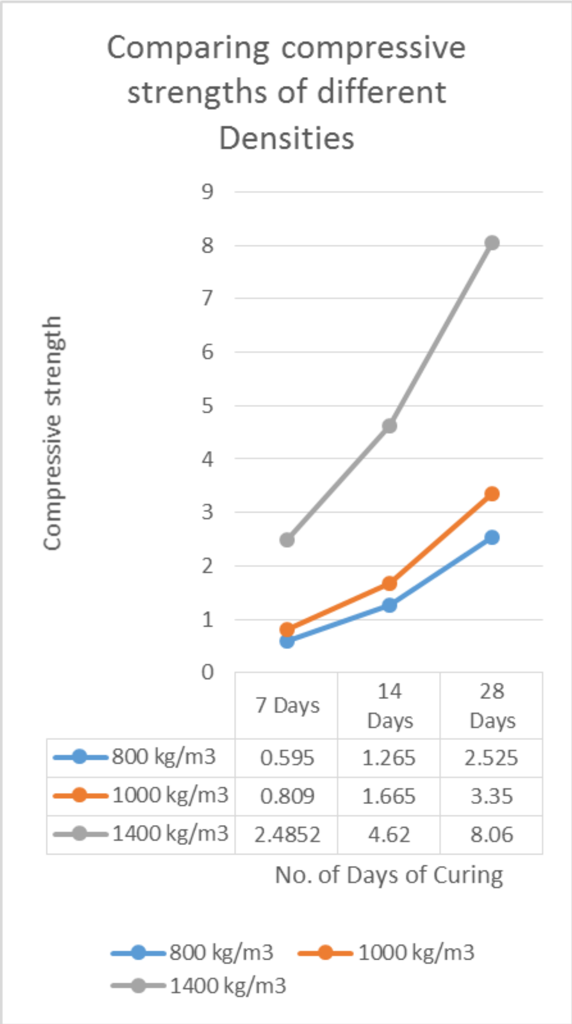

Fig-2 Compressive Strength Of Different Densities

From the below graphs it is inferred that maximum strength for both 1000 kg/m^3 and 1400 kg/m^3 is obtained at replacement of 30% with quarry dust. The 28 day strength for addition of 30% quarry dust for 1000 kg/m^3 and 14000 kg/m^3 are 4.16 and 9.82 N/mm^2 . Addition of quarry dust above 30 % we can see a decrease in compressive strength of foam concrete. This could be due to the fact that addition of more amount of quarry dust can lead to breaking of bubbles in foam concrete.

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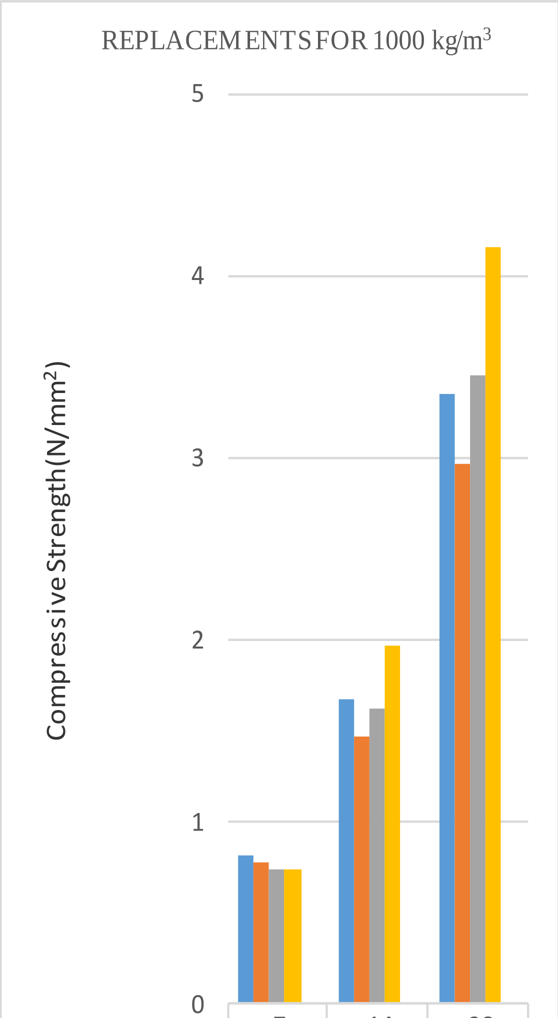
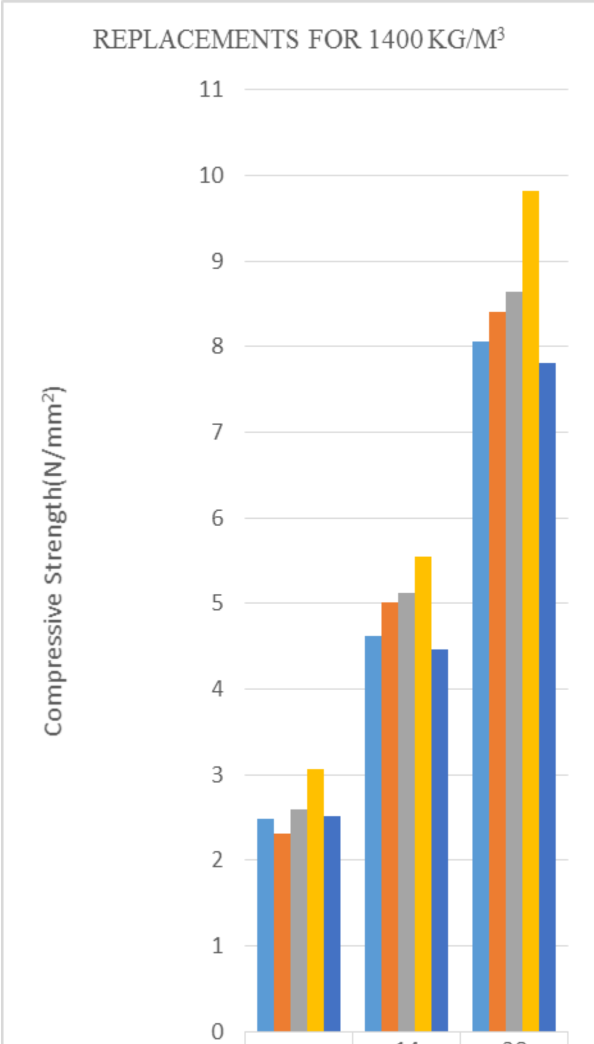


	7 days	14 days	28 days
0% Replacement	0.809	1.665	3.35
10% Replacement	0.768	1.46	2.97
20% Replacement	0.73	1.62	3.46
30% Replacement	0.738	1.96	4.16
40% Replacement	0	0	0

Fig Iii. Compressive Stregth For 1000 Kg/M3 Density With Quarry Dust Replacements.



	7 Days	14 Days	28 Days
0% Replacement	2.485	4.62	8.06
10% replacement	2.32	5.01	8.4
20% Replacement	2.6	5.12	8.64
30% Replacement	3.07	5.55	9.82
40% Replacement	2.51	4.471	7.8

Fig Iv. Compressive Strength For 1400 Kg/M^3 Density With Quarry Dust Replacements

VI. CONCLUSION

The compressive Strength of Foam concrete increase with increase in density of foam concrete. Higher Density does not always mean it has to give a higher strength. The water content also plays a major role in providing strength to foam concrete. Foam Concrete is more sensitive to water content than normal concrete. Concrete normally has a certain water demand to obtain workability. The strength of concrete decreases as the water-cement ratio increases. Ideal water/cement ratio is between 0.5-0.7.

Replacement of sand with quarry Dust will result in an increase in compressive strength of foam concrete. Replacement of sand with quarry dust should be limited to 30% as results show that replacement more that 30% results in decrease in compressive strength. This is due to the fact that addition of more amount of quarry dust will result in the breakage of bubbles which will lead to decrease in stability of the bubbles which will lead to decrease in compressive strength.

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REFERENCE

1) Brady. K.C, (2000), An Investigation into the Properties of Foamed Concrete, TRL Project Report PR/IS/99/00.
2) Brady. K.C and Greeno. M.J, (1997), Foamed Concrete: A Review of Materials, Methods of Production and Applications, TRL Project Report PR/CE/149/97.
3) Brady. K.C, Jones. M.R and Watts. G.R.A, (2001), Specification for Foamed Concrete, TRL Project Report PR/IS/40/01.(1-2)
4) Byun. K.J, Song .H.W and Park. S.S, (2010), Development of Structural Lightweight Foamed Concrete Using Polymer Foam Agent, Department of Civil Engineering, Yonsei University, Korea.(1-2)
5) Fahrizal Zulkarnain and Muhyuddin Ramli, (2011), Performance and Characteristic Foamed Concrete Mix Design with Silica Fume for Housing Development, School of Housing, Building and Planning, University Sains Malaysia, Penang.(8-9)
6) Jones. M.R, Aikaterini McCarthy and Ravindra. K. Dhir, (2005), Concrete Technology Unit, Division of Civil Engineering University of Dundee.(2-3)
7) Mangal Yadav, (2005), Mix Design Formulation of Foam Concrete, Feasibility Studies and Critical Appraisal of Application of Foam Concrete Blocks as Replacement to Burnt Clay Bricks.(1-3)
8) Norazila Binti Kamarulzaman, (2010), University Malaysia Pahang.An investigation into properties of foam concrete, (1-5)
9) Puttappa. C.G, Muthu. K.U and Raghavendra. H.S, (2008), Mechanical Properties of Foamed Concrete, MSR Institute of Technology, Bangalore
10) Ramamurthy. K, Nambiar .E.K.K and Indusiva Ranjani. G, (2009), A Classification Studies on Properties of Foam Concrete, Cement and Concrete Composites, Volume: 31, Issue: 6.
11) Ravindra. K. Dhir. Moray. D. Newlands and Aikaterini McCarty, (2005), Use of Foamed Concrete in Construction, University of Dundee.
12) M.S Shetty ‘Concrete Technology’ S.Chand vol-1, 1996 PG 513-514