Specification and Quality Control of Light Weight Foam Concrete

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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. The continuous research and development projects in concrete have resulted in the production of various types of concrete. Each type of concrete possesses their own some specific characteristics to get an optimum demand of organization and industrialization. One of the best types of concrete whose popularity increases rapidly now days are light weight foam concrete (LWFC). The synonyms of light weight concrete are Cellular Concrete, Foam Concrete or Aerated Concrete. This project describes the nature of foam concrete, its composition, its properties and its durability.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(protein based foaming agent) used. The target density of Foam concrete in between 800-1600kg/m^3. In this project foam is generated through open air mechanical stirring without using Foam generator and by maintaining foam to water ratio 1:25 which means 1 part of foam is added into 25 part of water. Then after, generated foam is now mixing into the cement slurry (cement, sand and fly ash is used in making cement slurry) and entrained about 30% air by volume into the foam concrete so that it attains a light weight concrete block when became hardening.**

Keyword: **- light weight foam concrete (LWFC), cellular lightweight concrete (CLC), without foam generator, fly ash, foaming agent.**

I. INTRODUCTION

Cellular concrete or Foam concrete was first developed in Stockholm, Sweden in the early of 1900's after the Second World War, this technology rapidly spread into the different parts of the world, mostly in the Europe and Soviet Union.

Foam concrete is a type of porous concrete. It can be treated as aerated concrete where the foam bubbles are formed through open air mechanical stirring using concrete hand mixer, after that an obtained foam are mixed into the water-cement slurry to make light weight Cement concrete. Basically Foam concrete is a mixture of cement, fly ash, sand, water and foaming agent. When the foaming agent is diluted with water and air, further it is mixed into the cement slurry. The water-cement slurry sets around the foam bubbles and this paste have sufficient strength to maintain its shape around the foam bubbles, it entrains 30-35% of air by volume into the concrete, as results the low density Foam Concrete is obtained. It may also float into the water. It can be categorized as cellular material because it contains higher amount of pores. Further quality of foam concrete is depending upon the quality and type of foam is used. As mostly no coarse aggregate is used in the production of the foam concrete or cellular concrete, the correct terms would be called mortar instead of concrete. The density of foam concrete generally varies from 800-1600kg/m^3.

Generally the main advantage of Foam Concrete is it can be placed easily by pumping if necessary and does not require any compaction, vibration or leveling. It can be called as highly workable concrete. It has excellent resistance against water and frost action. This research report is prepared to show the activities and progress of the light weight concrete.

II. MATERIAL USED

2.1. *Cement:* - cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material. Here Ordinary Portland Cement (OPC) is preferred in the making of Foam concrete. The physical properties of OPC used in this project are

- Color-white
- Density of cement- 1440kg/m^3
- Specific surface area-2250cm^2/kg
- Type- OPC grade 53
- Compressive strength-53MPa
- Codal provision- IS.269.1989 and IS.383.1970
- Chemical composition of cement

Compound	Chemical composition (in %)
CaO	57.84
SiO_2	20.33
Fe_2O_3	4.68
Al_2O_3	3.40

MgO	1.51
MnO	0.10
TiO_2	0.09
K_2O	0.72
Na_2O	0.51
SO_3	7.26
Loss on ignition	3.42
Insoluble residue	1.23

2.2. *Fly ash:* - Fly Ash particles are mostly spherical tiny glass beads. Ground materials such as Portland cement are solid angular particles. Fly Ash particles provide a greater workability of the powder portion of the concrete mixture which results in greater workability of the concrete and a lowering of water requirement for the same concrete consistency. The physical properties of fly ash used

- Type- Class C Fly ash
- Density of flyash- 1400kg/m^3
- Color- white
- Specific surface area-4000cm^2/g
- Codal provision- IS.3812.1.2003
- Chemical composition of fly ash

Chemical Component	Fly ash Chemical composition (in %)	
	Class C	Class F
SiO_2	40	55
Al_2O_3	16	26
Fe_2O_3	6	7
CaO	24	9
MgO	2	2
SO_3	3	1
Loss on ignition	6	6

2.3. *Fine Sand:* - Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone. Particle size of fine sand is less than 2mm. The specific gravity of sand used in this experiment is 2.6. The density of sand used is 2600kg/m^3 and having fineness modulus 2.63. Codal provision used IS.383.1970.

2.4. *Foaming agent:* - foaming agent is a chemical which facilitates formation of foam such as surfactants and blowing agents. There are two types of foaming agent:

I. Synthetic-suitable for densities of 1000 kg/m^3 and above.

II. Protein-suitable for densities from 400 to 1600 kg/m^3

- Protein-based foaming agents come from animal proteins (horn, blood, bones of cows, pigs & other remainders of animal carcasses). These surfactants might therefore be best suited to the production of foamed concrete of relatively high density &high strength.
- 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.

- Physical properties of foaming agent which are used in making foam concrete or CLC are Type- Protein based foaming agent, Color-brown, State-liquid, Specific gravity-1.15, Ph at 20ºC-6.5 to 7.5, water solubility- infinite, Freezing point -3 to -5 °C. Recovers fully after freezing, Dosage- 1:25 (1 part foaming agent liquid mix into 25 part of water).

2.5. *Concrete hand mixer:* - In this project concrete hand mixer is best suitable for mixing cement slurry and it is also used in generating foam volume. Some specification of concrete hand mixer are having mixer power-350W (or 0.5hp), rotating speed- 14000rpm, power supply- 220-240V/50Hz.

Fig.1. Concrete hand mixer

2.6. *Concrete mould:* - Standard size concrete mould is used (15*15*15) cm.

III. RESULTS AND DISCUSSION

The mix proportion of LWFC should be worked out such that it keeps the desired physical properties and compressive strength, sand to cement ratios are important as they are used to arrive at optimized concrete strength and water to cement ratio are carefully designed to obtain good workability as well as good binding property. Here LWFC are to be designated as Mix-A, Mix-B and Mix-C according to their increasing densities.

3.1. *Trail Mix-A:* - Keep water/cement ratio=0.77 by weight, cement:flyash:sand =1:1:0 by volume proportion is used, foaming agent:water= 1:25 is used and no sand content is required for this trail.

Finding the quantity of cement, flyash and sand with their proportions 1:1:0 (in which 1 part of cement, 1 part of flyash and no sand content is added). The mixture volume required 0.027m^3 which is equal to the volume of 8 standard concrete cubes. See Table.1

MixA = 1:1:0

Volume = 1+1+0=2

Total volume ingredients for using =0.027m^3

Volume of cement Require = (1/2) x 0.027 = 0.0135 m^3

Volume of flyash Require = (1/2) x 0.027 = 0.0135 m^3

Volume of sand Require = 0m^3

Density of cement=1440kg/m^3

Weight of cement require= 0.0135 x1440 = 19.44 kg

For 0.027m3 of Mix-A (1:1:0)

Flyash = 0.0135 m^3

Cement = 0.388bag

3.2. *Trail Mix-B:* - Keep water/cement ratio=0.77 by weight, cement:flyash:sand =1:1:0 by volume proportion is used, foaming agent:water= 1:25 is used and no sand content is required for this trail. See Table.1

Finding the quantity of cement, flyash and sand with their proportions 1:1:0.5

Mix-B = 1:1:0.5

Volume = 1+1+0.5=2.5

Total volume ingredients for using =0.027m^3

Volume of cement Require = (1/2.5) x 0.027 = 0.0108 m^3

Volume of flyash Require = (1/2.5) x 0.027 = 0.0108 m^3

Volume of sand Require = (0.5/2.5) x 0.027 =0.0054m^3

Density of cement=1440kg/^{m3}

Weight of cement require= 0.0108 x1440 = 15.552 kg

For 0.027m3 of Mix-B (1:1:0.5)

Flyash = 0.0108 m^3

Sand = 0.0054 m^3

Cement = 0.311bag

3.3. *Trail Mix-C:* - Keep water/cement ratio=0.77 by weight, cement:flyash:sand =1:1:1 by volume proportion is used, foaming agent:water= 1:25 is used and no sand content is required for this trail. See Table.1

Finding the quantity of cement, flyash and sand with their proportions 1:1:1

Mix-C = 1:1:1
Volume = 1+1+1=3
Total volume ingredients for using =0.027m^3
Volume of cement Require = (1/3) x 0.027 = 0.009 m^3
Volume of flyash Require = (1/3) x 0.027 = 0.009 m^3
Volume of sand Require = (0.5/3) x 0.027 =0.009m^3
Density of cement=1440kg/m^3
Weight of cement require= 0.009 x1440 = 12.96 kg
For 0.027m3 of Mix-B (1:1:0.5)
Flyash = 0.009 m^3
Sand = 0.009 m^3
Cement = 0.2592bag

Table.1.Mix proportions of Foam concrete

Mix proportions	Cement (in m^3)	Flyash (in m^3)	Sand (in m^3)	Water (in litre)	Foaming agent (in litre)	Foam volume (in litre)
Mix-A	0.0135	0.0135	0	6	0.24	24
Mix-B	0.0108	0.0108	0.0054	6	0.24	24
Mix-C	0.009	0.009	0.009	6	0.24	24

Fig.2. LWFC of Mix-A

3.4. ***Density, compressive strength and water absorption of Mix-A, Mix-B, Mix-C are been tabulated.***

Table.2. Mix-A

1 specimen= 3samples	Density (in kg/m^3)	Compressive strength (in N/mm^2)	Water absorption (in %)
Sample1	796	2.98	12.5
Sample2	799	3.00	12.4
Sample2	800	3.01	12.45
Average of above three	798.34	2.997	12.45

Table.3. Mix-B

1 specimen= 3samples	Density (in kg/m^3)	Compressive strength (in N/mm^2)	Water absorption (in %)
Sample1	1036	3.82	12.01
Sample2	1033	3.86	11.90
Sample2	1034	3.90	12.03
Average of above three	1034.33	3.86	11.98

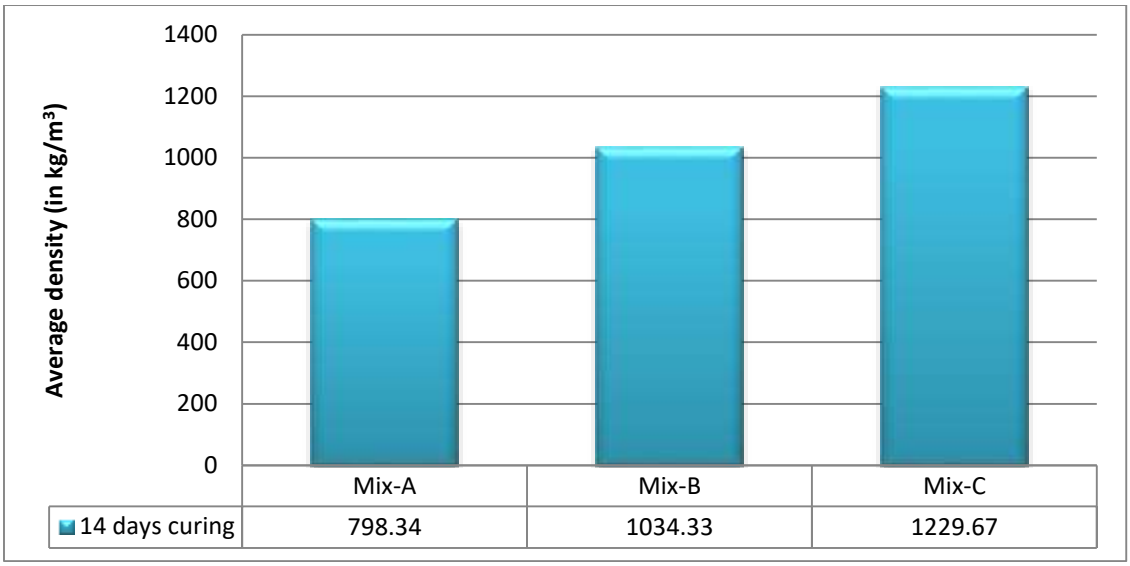
Table.4. Mix-C

1 specimen= 3samples	Density	Compressive strength	Water absorption
Sample1	1228	6.81	10.9
Sample2	1230	6.85	10.11

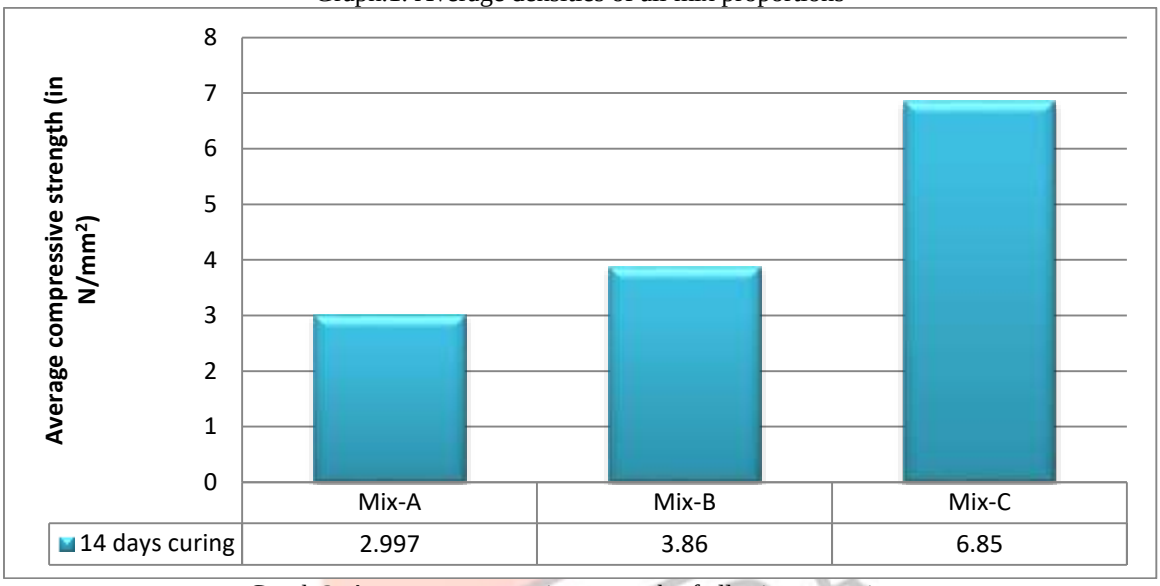
Sample2	1231	6.88	10.3
Average of above three	1229.67	6.85	10.43

Fig.3. Compressive strength of concrete

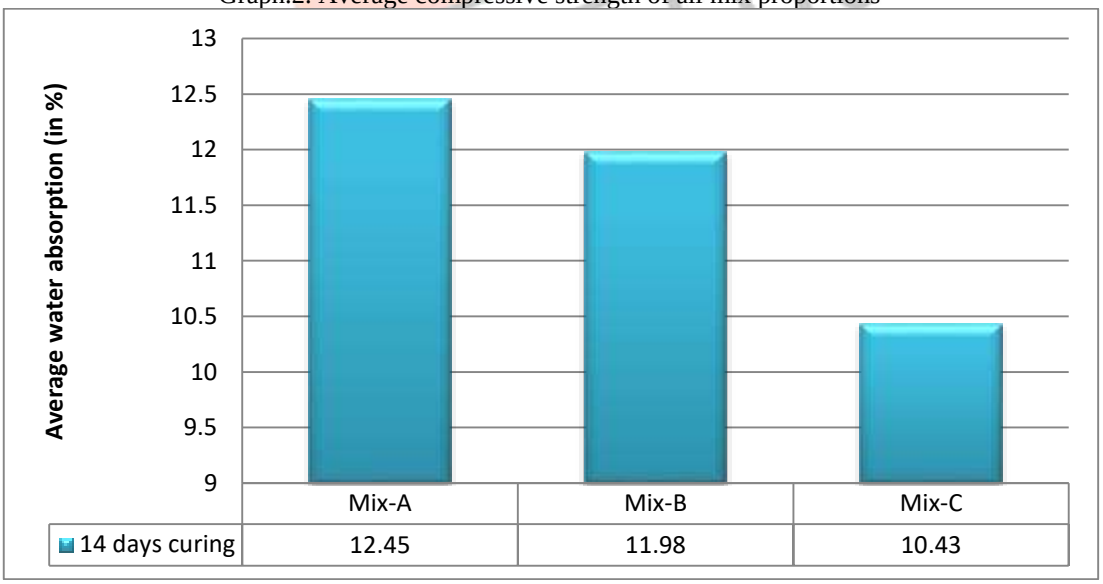
Fig.4. Floating concrete



Graph.1. Average densities of all mix proportions



Graph.2. Average compressive strength of all mix proportions



Graph.3. Average water absorption of all mix proportions

IV. CONCLUSION

The main purpose of this paper is to determine the workable and durable properties of LWFC without using Foam generator, while foam is generated through open air mechanical stirring in which there will be some possibility of entraining air into it as does in foam generator although the cost of construction is comparative low. In this experiment the effect of flyash in LWFC is also a part of attraction. Flyash consists cementitious properties by which it imparts good strength to LWFC and having finess particles it

fulfills the partial replacement of fine sand also. In this experiments we conclude that if we increasing the quantity of sand particles the density of trail mixes are also increases and as similar their compressive strength are also increases which are shown in Graph.1 and Graph.2. Mix-A and Mix-C concrete can be classified as low density LWFC (in Table.2 and Table.3) which means they are not used as load bearing structures therefore it can be used in making kerbs, median, non-bearing structures in highways and expressways, in navigational purposes, agricultural purposes etc. while Mix-C concrete can be classified as medium density LWFC which means it can be used as load bearing structures. Medium density LWFC are used in walls, slabs, pre-cast blocks or of any other types of Reinforced Pre-cast elements like cladding units etc.

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