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Design and Analysis of Foam Concrete

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ABSTRACT

The foam concrete name itself define the character of the concrete that being light weight concrete made out of a foaming agent which doesn't have coarse aggregate in it as a mixture, and could also termed as aerated mortar since it having air voids in it. The foaming agent is added separately to the cement paste which dilutes with water in forming foam when it is sprayed out of pump.

The mixture is having more water content in order to produce more bubbles with the foaming agent while the concrete mixture have enough strength to be in certain shape around the air voids to get stiff. The mixture should have enough water content added to it because of if the water content if excess, then the mixture couldn't hold the bubbles by separates bubbles form mixture and if it is lower then it gets stiffens. The water-cement (w/c) ratio of foam concrete used will be in 0.4 – 1.25 where as it varies according to the purpose of usage.

It is designed to have any density within the dry density range of 300-1850kg/m3. In this project foam concrete blocks are prepared according to the designed proportions to attain the maximum strength of 1900kg/m3.cubes are prepared by a designed mix and there by tested for their density and also compressive strength the results are reported

Keywords: Foam concrete, Light weight, Density and strength

I. INTRODUCTION

1.1 BACKGROUND:

Foam concrete is a type of porous concrete. According to its features and uses it is similar to aerated concrete. The synonyms are aerated concrete, lightweight concrete or porous concrete. The term foam concrete is containing no aggregates only sand, cement, water and stable foam to perform the concrete. This action incorporates small enclosed air bubbles within the mortar there by making the concrete lighter.

Basically, there are two method of producing foamed concrete such as prefoam method and inline method. The inline method can divided into wet method and dry method. To produces foamed concrete, aerated concrete(flow chart:1.1 aerated concrete) there are two type of foam will be used by wet foam and dry foam. A foamed concrete is described as having an air content of more than 25% which distinguishes it from highly air entrained materials. Foamed concrete may have density from as low 500kg/m^3 to 1600kg/m^3 and strength from less than 1N/mm^2 to 25N/mm^2.

1.2 CONSTITUENTS OF FOAM CONCRETE :

[Deijk, 1991]The essential components in foam concrete are binder, water and foam. Optionally, sand, fiber, filler and additives such as water-reducing agent, setting-controlling agent, etc. can be added according to the practical requirement.

1.1.1 BINDER

The most commonly used binder is cement, but other supplementary materials such as silica fume, fly ash, slag or waste, can also be included in as long as their acceptability has been demonstrated. The addition of supplementary materials as partial replacement to the binder can enrich the concrete with various desirable properties in its fresh and hardened states [Narayanan and Ramamurthy, 2000]. Binder can be even materials without cement. For example, the successful use of binder made of ground granulated blast furnace slag plus low value liquid glass **[Beljakova et al., 1998]**, and magnesite powder **[Vinogradov et al., 1998]** in foam concrete were reported.

1.1.1.1 Cement

ACI 523.1R-92 [American Concrete Institute, 1992] recommends the use of Portland cement or Portland blast furnace slag cement which conforms to the respective ASTM

Specifications:

C 150 [American Society for Testing and Materials, 1994], Type I or Type III;

Type IA or Type IIIA; C 595 [American Society for Testing and Materials, 1994] , Type IS or Type IS-A. It also points out that High-early-strength cements (Type III or IIIA) are often used to advantage the production of low density concrete. The practical use of finely-ground cement, high-early-strength Portland cement and rapid setting hydraulic cement were reported by **Fujiwara et al [1995], Johansson et al.[1999] and Hashimoto et al.[1976]**, respectively.

1.1.1.2 Supplementary material

Spinnery [1993], in his patent of producing non-shrinking foam concrete, has reported replacing cement with an equal amount of cementitious fines which can be fly ash (Type F and C), slag cement and kiln dust or non-cementitious fines which can be limestone, silica and granitic fines. **Fujiwara et al. [1995]** reported the use of binder comprising high-early-strength Portland cement, silica fume and ultra-fine silica stone powder to produce high-strength foam concrete. The mean particle size of ultra-fine silica stone powder of 2.4μm, is approximately the square root of the product of the mean particle size of the silica fume, 0.1μm, and that of cement, 20μm, which is expected to have densification effect and increase the strength of the resulting paste. His study also showed that the combination of 10% silica fume, 30% ultrafine silica stone powder and 60% cement resulted in the most satisfactory workability and compressive strength among all the trial mixes. The 28-day compressive strength of the foam concrete with wet density of 1500 kg/m^3 was around 50 MPa. **Kamaya et al. [1996]** pointed out that it is preferable to use non-organic materials, which have specific surface area higher than 7500 g/cm^2 as supplementary material, for the production of high-strength foam concrete, otherwise the strength of the resultant foam concrete will be drastically reduced.

Kearsley and Visagie [1999] reported that, using unclassified fly ash, of which around 40% of the particles have diameters exceeding 45 μm, the 56 day compressive strength of foam concrete with wet density of 1500 kg/m^3 could achieve around 45 MPa,. Although the compressive strength of foam concrete produced by Kearsley and Visagie is lower than what Fujiwara et al. have produced at the same density, the former is still significantly higher than the conventional foam concrete. Therefore, it seems that, without using ultra fine material such as silica fume or materials with fineness higher than 7500 g/cm^2, the production of high strength foam concrete is still possible.

II. MIXING WATER

According to ACI 523.3R-93 [American Concrete Institute, 1993], mixing water for foam concrete should be fresh, clean and drinkable. This is particularly important when using protein-based foaming agents as any organic contamination could have an adverse effect on the quality of the foam produced [British Cement Association, 1991]. Undrinkable water could also be used only if the resulting foam concrete has 7- and 28-day strengths equal to at least 90% of the strength of similar specimens made with water from a municipal supply. The strength comparison should be made on mortars, identical except for the mixing water, prepared and tested in accordance with ASTM C109 [American Society for Testing and Materials, 1993].

2.1.3 FOAM

The low specific gravity of foam concrete is achieved by introducing foam bubbles in the cement paste and the concrete produced. Foam bubbles are air voids enclosed by the wall of a solution of foaming agent. Common foaming agents are synthetic agents such as resin soap, and protein-based foaming agents such as hydrolyzed protein **[India Concrete Journal, 1989; Deijk, 1991]**. Preformed foam, as described by ACI 523.3R-93 [American Concrete Institute, 1993] is produced by blending the foaming agent, water and compressed air (generated by an air-compressor) in predetermined proportions in a foam generator calibrated for a discharge rate.

The quality of foam is affected by its density, the dilution ratio of the agent, the foaming process, the pressure of the compressed air, and the adding and blending process with the mortar. In addition, a suitable workability of the mortar is vital for the uniform introduction of foam **[Kamaya et al, 1996]**. This quality of foam is evident from the stability of the foam concrete and will consequently affect the strength and stiffness of the resultant foam concrete **[Beljakova et al., 1998]**. To ensure the quality of the foam, a minimum dilution ratio of foaming agent and a minimum air pressure must be achieved. Furthermore, the foam must be added immediately after it is produced, whilst it is still stiff. Method of improving the stability of foam by adding a foam stabilizing fluorinated surfactant into the foam concrete has been described in US patent no. 6153005 **[Welker et al., 2000]**.

2.1.4 FINE AGGREGATE

The most commonly used inorganic fine aggregate is sand. According to ACI 523.1R-92 [American Concrete Institute, 1992], sands conforming to ASTM C33 [American Society for Testing and Materials, 1993], Concrete Aggregates, and C 144 [American Society for Testing and Materials, 2002], Aggregate for Masonry Mortar, are acceptable for production of foam concrete. Sands of other gradations may be used where their acceptability has been demonstrated.

The British Cement Association [1991] recommends that building sand or concreting sand of 5mm maximum size may be used, and it is reported that, based on the research findings, for a given cement content, a higher strength was obtained using sand with maximum size of 2 mm and with 60 to 95% passing the 600 micron sieve. Waste sands, such as single-sized tailings and granite dust, have been used successfully, but the same restrictions on grading and maximum size still apply [British Cement Association, 1991]. Foam concrete with improved strength using ground quartz sand with specific surface at least 2900 g/cm^2 was reported by Votintsev and Mironova [1999]. Conclusively, the fineness of sand is important for the strength of foam concrete. The use of finer sand can improve the strength of resultant foam concrete. Fine aggregate can be not only natural or crushed sand, but also artificial fine particles as long as their usability can be proved.

Organic fine particles such as polystyrene pellet [**Rodgers, 1996**] and polymer micro-particles **[Hedberg and Berntsson, 1990]** can also be used to partially or totally replace the sand as fine aggregate in foam concrete. They normally have a lower specific gravity than that of sand and therefore help to further reduce the weight of foam concrete or improve the strength of foam concrete when its density is maintained. Some materials have not been reportedly used to produce foam concrete but the use of them may bring significant economical effect. One example is middle-east sand, which is generally considered not suitable to be used as concrete making material **[Kay et al., 1994, Fookes and Collis, 1975]**. Compared to normal sand, middle-east costal sand has poor grading and high content of chloride and sulphate salts. Bleeding, segregation, lower strength and poor durability of concrete have reportedly been encountered when it is used for producing normal mortar. However, inland dune sand which is a type of middle-east sand has low content of chloride and sulphate salts. Compared with commonly used sand, inland dune sand has smaller particle size, smoother surface texture and particle shape which is closer to spherical. These features make the use of inland dune sand in foam concrete possible.

2.1.5 FIBER

The use of fibers helps to reduce the non-load cracking of foam concrete at early ages [American Concrete Institute, 1993]. Fibers for this purpose must have a high modulus of elasticity and be of sufficient length, size and number to develop the required tensile resistance at any section. The introduction of fiber reinforcement can transform the basic material character of cellular concrete from brittle to ductile elasto-plastic behaviour. Fiber reinforcement contributes to the improved flexural strength, energy absorbing (toughness) capabilities and post cracking behavior **[Zollo and Hays, 1989]**. Fibers that can be used in foam concrete are: Glass fiber, synthetic fiber and carbon fiber. ACI committee 544 [American Concrete Institute, 2002] has reported the information on fiber types and sizes, and methods of handling, mixing, and placing concrete containing fibers. Glass fibers are often used in cellular concrete. Synthetic fibers such as polyamide fiber**[Morgun et al., 1999]**, polyvinyl alcohol fiber**[Kenji &Mitsuo, 1989]**, polypropylene fiber**[Castro and Moran, 2001]** have been successfully used to produce foam concrete. Carbon fiber can also be used but its cost could be too high. Steel fibers are not suitable to be used in foam concrete as they may settle to the bottom of the concrete mixture. The suitable fiber volume fraction is from 0 to about 3%. When fiber volume fraction ranged from 0.1 to 1%, the effect of restrain in shrinkage cracking became more significant **[Grzybowski and Shah, 1990].**

The size of fiber is generally expressed in the unit of denier, which is a weight-perunit-length measure of any linear material. Officially, it is the number of unit weights of 0.05 grams per 450-meter length. This is numerically equal to weight in gramsof 9,000 meters of the material. Denier is a direct numbering system in which the lower numbers represent the finer sizes and the higher numbers the coarser sizes.

2.1.6 WASTE OR RECYCLED MATERIAL

Many people have reported the successful use of waste or recycled materials, such as sewage sludge ash [cook and walker, 1999], crushed excavated material **[etherton, 2001]**, slaked lime **[masao et al., 1991]**, crushed broken ceramic bricks **[vinogradov et al., 1998]**, and the waste from the combustion of brown coal **[siejko and jatymowicz, 1978]**, as the constituent material of foam concrete.

2.1.7 ADMIXTURES OR ADDITIVES

Admixtures or additives may be used when a specific change in the properties of the freshly mixed or hardened concrete is desired. ACI 523.3R-93 [American Concrete Institute, 1993] specifies that admixtures should conform to ASTM C260 [American Society for Testing and Materials, 1994] and C494 [American Society for Testing and Materials, 1992]. Commonly used admixtures are: water-reducing agent, water repellents, retarders and accelerators. For foam concrete made by pre-foaming method, it is imperative to maintain a sufficient workability of the premixed mortar (or paste) without foam to ensure the successful introduction of foam.

Therefore, the addition of water-reducing agent would be necessary for the production of high-strength foam concrete which generally has low water/binder ratio. **Fujiwara et al. [1995]** described production of a high-strength foam concrete, of which the amount of water was only 0.19 that of the total mass of cement, silica fume and ultra-fine silica stone powder. To obtain a flow value of around 180mm, measured in accordance with JISR5201[Japanese Architectural Association, 1998], the dosage of super plasticizer was 3% by weight of the blended powder. Admixtures may react adversely with the foaming agent **[Deijk, 1991],** thus when any admixture is used in foam concrete, the compatibility of the admixture with the other constituents in the mix should be determined by tests [American Concrete Institute, 1993].

2.1.8 OTHERS

Foam concrete can be coated or impregnated **[Terajima and Harada, 1998, Jun et al., 1992]** with resin or polymer to acquire high strength and water resistance.

Coarse natural aggregates cannot be used because they will segregate in the lightweight foam concrete, but it is possible to use lightweight aggregate with a similar density to the foam concrete. This will avoid segregation, improve the strength for a given density and reduce the higher drying shrinkage associated with the lower density mixes [British Cement Association, 1991].

2.2 MIX PROPORTION OF FOAM CONCRETE

The variation in mix proportion has a strong effect on the material properties of foam concrete. Altering the cement content and/or the water/cement ratio with a constant density has an impact on the strength and stiffness. Increasing the aggregate and/or filler content with a constant density decreases the shrinkage and crack sensitivity and can improve the toughness.

The change in density has an enormous impact on the thermal insulation capacity, the strength, the stiffness and the water absorption of the material **[Deijk, 1991].** Therefore, mix proportion must be chosen according to the practical requirements such as strength, shrinkage, thermal conductivity, etc.

The early work reviewed by **Valore [1954]** and **Taylor et al. [1969]** indicated thatproportions were selected through trial mixes using three parameters: sand/cement ratio,water/cement ratio and density of the mix.

ACI 523.3R-93 [American Concrete Institute, 1993] reports that the mix proportioning begins with the selection of the unit weight of the plastic concrete (wet density), the cement content, and the water-cement ratio. The mix can then be proportioned by the method of absolute volumes. The sum of the absolute volumes of cement, water, and aggregate for one cubic meter of concrete determines the volume of air required per cubic meter of concrete. The relation between air volume and foam volume can be calculated according to the density of the foam measured, which has been explained in ASTM C-769 [American Society for Testing and Materials, 1993]. Lim [1984] obtained various mix proportions by fixing the cement content and altering the density and water to cement ratio. **Fujiwara et al. [1995]** first chose an optimal binder composition by studying the strength and workability of the resulting paste. A low water/binder ratio equal to 0.19 was adopted in the mixture. Thereafter the exact binder and water content were calculated based on the density of the foamed paste.

2.2.1 CEMENT OR BINDER CONTENT

The average cement content in conventional foam concrete with or without sand ranges from 250 to 500 kg per cubic meter of concrete [Indian Concrete Journal, 1989; American Concrete Institute, 1993; Valore, 1954; E-A-B Associates Bayley-Edge Limited; American Society for Testing and Materials, ASTM C796, 1993; Lim, 1984]. Cement contents for the most commonly used mixes are between 300 and 375 kg/m^3 [British Cement Association, 1991]. Binder content of 924.4 kg/m^3 and 1260.5 kg/m^3 were adopted for high strength foam concrete with density around 1100 kg/m^3 and 1500 kg/m^3 [Fujiwara, 1995].

2.2.2 WATER/BINDER RATIO

In Valore's [1954] work, for mixes with lower densities, higher water/cement ratios were used for each sand/cement ratio; but for mixes at the same density, the water/cement ratios were increased with the increased proportion of sand. He further noted that for cellular concretes in general, it is customary to gauge the proper amount of water in a mix by consistency rather than by a predetermined water/cement ratio.

For foam concrete without water reducing agent, the amount of water must be sufficient to ensure that the workability of the premixed paste or mortar is satisfactory for foam introduction [British Cement Association, 1991]. Otherwise the cement absorbs water from the foam, causing rapid degeneration of the foam [Kearsley, 1999]. Therefore for foam concrete with certain binder content and with certain type and gradation of sand, there is a minimum water/binder ratio for each density range [Lim, 1984]. On the other hand, the workability of the mortar should not be too high; otherwise the foam bubbles tend to separate, which brings about unfavourable bulk density difference between the upper part and the lower part of the shaped body [Narayanan, 1999, Masao et al., 1991]. In general, the optimum water/cement ratio for the premixed paste/mortar lies between 0.5 and 0.6 [British Cement Association, 1991].

The advent of superplasticizer makes it possible to produce foam concrete with not only very low water/binder ratio but satisfactory workability as well. Mortar or paste withwater/binder ratio of only 0.19 and 0.17 have been reported [Fujiwara et al., 1995, Kamaya et al., 1996] for the production of high-strength foam concrete. Instead of using the water/binder ratio of the foam concrete as one of the parameters, some researchers use the water/binder ratio of the paste before the introduction of the foam as one of the parameters [Fujiwara et al, 1995].

2.2.3 SAND/BINDER RATIO

Conventional foam concretes made in Europe generally have sand/binder proportions of 1:1 to 4:1. McCormick [1967] observed that the effect of varying the sand content appeared inconsequential with respect to compressive strength when the sand/cement ratio was ranged from 1.0 to 2.0.

In the mix design recommended by ACI committee 523 [American Concrete Institute, 1993], sand/cement ratio was obtained as a dependent variable after the mix density, the cement content and the water/cement ratio have been decided. The sand/cement ratio thus obtained ranged from 0.29 to 3.66 for mixes of densities ranging from 800 to 1920 kg/m^3 at various cement contents and water/cement ratios.

2.3 PROCESS OF PRODUCTION

2.3.1 MIXING

Component materials can be added into mixer by three different sequences:

i) dry material water with admixtures dissolved in foam [Valore, 1954]

ii) water with admixtures dissolved in dry material foam [American Concrete Institute, 1993]

iii) partial water partial dry materials partial water partial dry materials foam [E-A-B Associates Bayley-Edge Limited]

The density of the mortar before and after the introduction of foam shall be checked for the control of density of foam concrete [E-A-B Associates Bayley-Edge Limited]. Avariation from above mentioned sequences is also allowed if it can be shown to be advantageous.

Omni mixer [Fujiwara et al., 1995] and gravity type mixer [E-A-B Associates Bayley-Edge Limited] have been reportedly used for the production of foam concrete. ASTM C 796 [American Society for Testing and Materials, 1993] recommended that the mixer for mixing foam concrete in laboratory shall be a powder-driven paddle type mixer with a capacity of 0.12m^3, an operating speed of 40 to 45 rpm, and equipped with rubber wiper blades.

III. METHODOLOGY

Foresight groups around the world, future need for construction materials that are light, durable, and simple to use. The alternative material that has the potential to fulfill all these requirements is foamed concrete.

- Mix Design of Foam concrete
- Preparation and casting of Foam Concrete Cubes & Cylinders
- Comparison of compressive strength of foam concrete
- Comparison of Foam concrete with other factors like Cost effectiveness, suitability, etc…

Foam concrete mixture with different ingredients of the materials is used in this investigation. The physical properties (Density) as well as a specific structural property (compressive strength) of foam concrete mixtures were obtained first, before the relationship between these properties were determined. Foam Concrete cubes are prepared and the tests are performed in college laboratory.

3.1 MIX CONSTITUENT PROPORTIONS AND FOAM CONCRETE PRODUCTION

Although there are no standard methods for proportioning foamed concrete, the general rules regarding w/c ratio, free water content and maintaining a unit volume apply, but it is a specified target plastic density that becomes a prime design criterion. It should be noted that it is difficult to design for a specific dry density, as foamed concrete will desorb between 50 and 200 kg/m^3 of the total mix water, depending on the concrete plastic density, early curing regime and subsequent exposure conditions. The trial and error process is often adopted to achieve foam concrete with desired properties (Nehdi2001). (flow chart:3.1 classification of production method for foam concrete)For a given mixture proportion and density, a rational proportion method based on solid volume calculation was proposed by McCormick (1967). ASTM C 796-97 provides a method of calculation of foam volume required to make cement slurry of known w/c ratio and target density. For a given 28 days compressive strength, filler-cement ratio, and fresh density, typical mixture design equations of Nambiar and Ramamurthy (2006b) determine mixture constituents (i.e., percentage foam volume, net water content, cement content, and percentage fly ash replacement). Most of the methods help in calculation of batch quantities if the mixture proportions are known. Even though the strength of foam concrete depends on its density, the strength can be increased by changing the constituent materials for a given density. In addition, for a given density, the foam volume requirement depends on the constituent material (Nambiar and Ramamurthy, 2006b). Hence, for a given strength and density requirement, the mixture design strategy should be able to determine the batch quantities. Assuming a given target plastic density (D, kg/m^3), water/cement ratio (w/c) and cement content (c, kg/m^3), the total mix water (W, kg/m^3) and fine aggregate content (f, kg/m^3) are calculated from equations (1) and (2) as follows.

Target plastic density, $D = c + W + f$

Where c = PC +FA fine,

f = FA coarse + sand

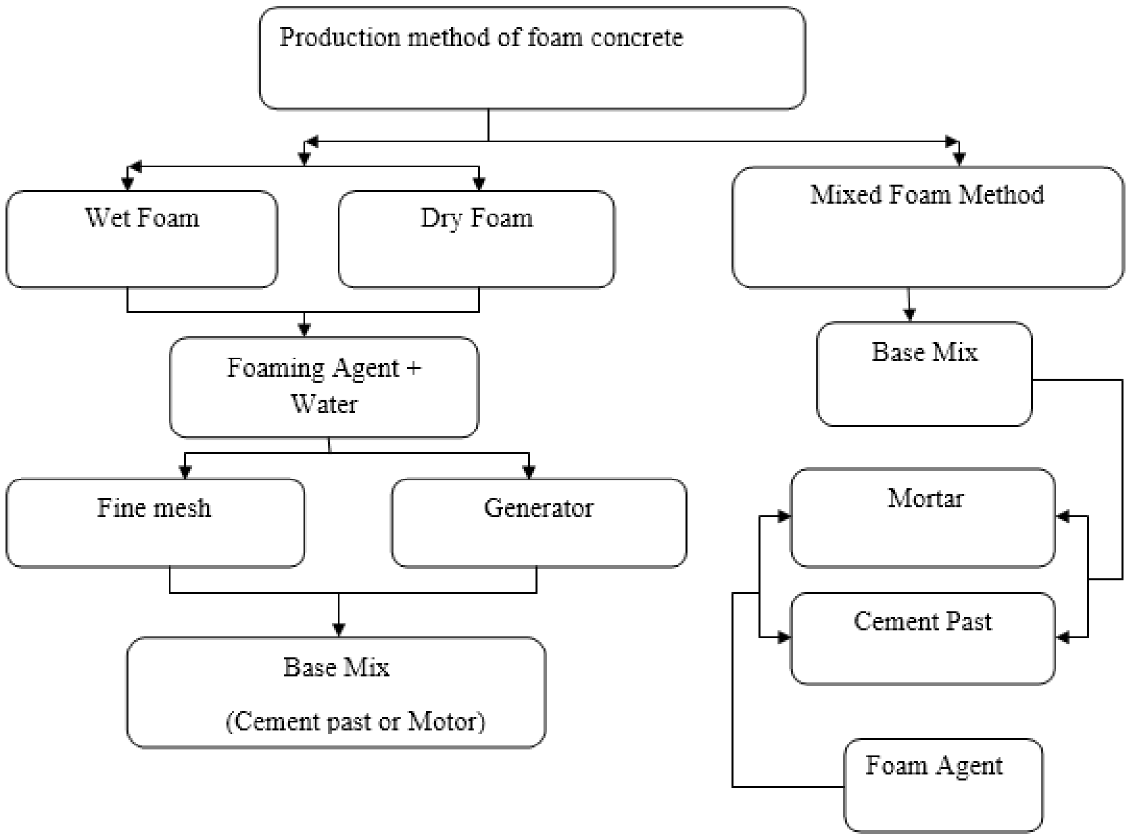
Free water content,

W = (w/c) X (PC + FA fine +FA coarse)

Foamed concrete was produced in the laboratory using a standard inclined rotating drum mixer by the addition of pre-formed foam to a mortar (i.e. mix with sand fine aggregate) or paste (i.e. mix with no sand, just FA coarse fine aggregate) 'base' mix and mixing until uniform consistency was achieved. The plastic density was measured in accordance with BS EN 12350-611 by weighing a foamed concrete sample in a pre-weighed container of a known volume. A tolerance on plastic density was set at ± 50 kg/m^3 of the target value, which is typical of industry practice for foamed concrete production. The specimens were then cast in steel moulds lined with domestic plastic 'cling' film, as foamed concrete was found to adhere strongly to the mould surface, irrespective of the type and quantity of release agent used.

After de-moulding at 24 hrs, the specimens were sealed-cured (i.e. wrapped in 'cling' film) and stored at 20ºC until testing. It is recognized that sealed-curing may result in specimens having different degrees of pore saturation. This effect was considered to be minor for the range of constituent materials studied and certainly more representative of the actual properties of the material than would be the case if standard curing was applied. Again, sealed-curing reflects typical industry practice for foamed concrete.

Flow chart:3.1 Classification process of production method for foamed concrete



3.2 EXPERIMENTAL PROCEDURE

Foamed concrete mixtures with and without sand for same target plastic density are therefore used in this investigation and the method used to determine the physical (Density) as well as a specific structural property (compressive strength) of the foamed concrete mixtures.

3.2.1COMPOSITION OF FOAM CONCRETE MIXTURE

The foamed concrete used in this research is produced under controlled conditions from cement, fly ash, sand, water and pre-formed foam. The cement used is 53 grade Ordinary Portland cement, locally available sand, fine fly ash (P60) IS certified having density 960 kg/m^3, foaming agent for produce the foam and water has been used for producing foam concrete.

Foam is a very important factor for the foam concrete. Foam was generated by using man power. for producing the foam foaming agent has been used, foaming agent is diluted with water in a ratio of 1:10 and then aerated to a density of 74 kg/m^3.

3.2.2 CURING

Lightweight Construction Methods (LCM) requires a curing means and period identical to that of conventional concrete. It is essential, as in conventional concrete, that cement-based elements have moisture for hydration at an early age. This is particularly true in the presence of direct sunlight that is known to cause rapid dehydration of concrete surfaces; curing compound can be applied as an alternative barrier. Full time continuous curing has been done in the laboratory.

3.2.3 COMPRESSIVE STRENGTH

The 150 mm test cubes were cast in steel mould and de-moulded after ± 24 hours. Then it was kept for curing in a constant temperature room up to the day of testing. The cubes were crushed on a more sensitive press (on compression testing machine) the usually used for normal concrete. Three cubes from the same mixture of foamed concrete were crushed and the average of the three results is used to define the strength of the mixture (According to IS: 516-

1959). The compressive strength was recorded to the nearest 0.1 MPa. Compressive strength of foamed concrete was recorded for 7, 14 and 28 days.

3.2.4 DENSITY

The test specimens (cubes) cast for this study have a dimension of 150mm X 150mm X 150mm. The initial density of the specimens as measured during manufacturing is casting density and it can be compared with designed density or in other words the target density. Test specimens are de-moulded within 24 hours of casting and after de-moulding, each specimen is cured in constant temperature room for 7, 14 and 28 days. The density was again measured at the time of determination of compressive strength this density is known as test density.

3.3 MATERIAL USE IN EXPERIMENT :

Assuming a target plastic density of 1900 kg/m^3

Water-cement ratio W/C is 0.35 (assuming)

Proportion =1:2.5 (Cement: FA)

Foaming agent =0.14% (cement weight)

D = c + w + f

1900= 500+170+1250

1900=1920kg/m^3

TABLE3.1:Mix design of foam concrete become

WATER	CEMENT	FA
170	500	1250
0.35	1	2.25

Table : 3.2

Trials:For Foam Concrete Mix – 1 (Containing Cement&Fine Aggregates)

Considering cement: fine aggregates in 1:2.5 proportion

Materials	Values
Cement	500kgs
Fine aggregates	1250kgs
Foam	0.90liters
w/c	0.35%

Table :3.3

Trials: For Foam Concrete Mix – 2 (Containing Cement, Blast Furnace Slag & Fine Aggregates &Fly Ash)

Considering cement: FA (blast furnace slag, fine aggregates,fly ash) in 1:2.5 proportion.

Fine aggregates = fine aggregates+ blast furnace slag+ flyash = 40%+50%+10%

Material	Values
Cement	500kgs
Fine aggregate	500kgs
Blast furnace slag	625kgs
Fly ash	125kgs
Foam	0.90liters
w/c	0.35

Table : 3.4

Trials: For Foam Concrete Mix – 3 (Containing Cement, Blast Furnace Slag & Fine Aggregates& Glass Powder)

Considering cement: FA (blast furnace slag ,fine aggregates , fly ash ,Glass powder) in 1:2.5 proportion.

Fine aggregate = fine aggregates + blast furnace slag +fly ash + Glass powder=35% +50%+5%+10%

Materials	Values
Cement	500kgs
Fine aggregates	437.5kgs
Blast furnace slag	625kgs
Fly ash	62.5kgs
Glass powder	125kgs
Foam	0.90liters
w/c	0.35

3.6 Foam concrete in comparison with other materials.

- When comparing foam concrete with other materials, one must keep in mind that:
- It is ecologically clean, "breathes", uninflammable.
- easy to produce in steady-state conditions as well as on a construction site
- is produced from components available in any region
- its prime cost is low

3.7 ADVANTAGES

- **RELIABILITY**

Foam concreteis an almost ageless and everlasting material not subject to the impact of time. It does not decompose and is as durable as rock. High compression resistance allows to use produce with lower volumetric weight while construction, which increases the temperature lag of a wall.

- **MICROCLIMATE**

Foam concrete prevents loss of heat in winter, is humidity proof, allows to avoid very high temperatures in summer and control air humidity in a room by absorbing and output of moisture, thus helping create a favourable microclimate (Microclimate in a wooden house).

- **QUICKNESS OF MOUNTING**

Small density, and, therefore, lightness of foam concrete, large sizes of blocks compared with bricks, allow to increase the speed of laying by several times. Foam concrete is easy to process and trim – to cut channels and holes for electrical wiring, sockets, and pipes. The simplicity of laying is reached through high exactness of linear dimensions, the tolerance is +/- 1 mm.

- **ACOUSTING INSULATION**

Foam concrete has a relatively high property of acoustical absorption. In buildings constructed of porous concrete the acting requirements for acoustic insulation are met.

- **ECOLOGICAL COMPATIBILITY**

During maintenance, foam concrete does not produce toxic substances and in its ecological compatibility is second only to wood. Compare: the coefficient of ecological compatibility of porous concrete is 2; of wood – 1; of brick – 10; of keramzite blocks – 20.

- **APPEARANCE**

Due to high workability, it is possible to produce various shapes of corners, arches, pyramids, which will attach beauty and architectural expressiveness to your house.

- **ECONOMY**

High geometrical exactness of dimensions of concrete produce allows to lay blocks on glue, to avoid "frost bridges" in a wall and to make inner and outer plaster thinner. Foam concrete weighs from 10% to 87% less than standard heavy concrete. Sufficient reduction of weight leads to sufficient economy on basements.

- **FIRE SAFETY**

Foam concrete produce protect from fire spread and correspond to the first degree of refractoriness, which is proved by tests.

Thus, it is can be used in fire-proof constructions. Under the impact of intensive heat, like blow lamp, on the surface of foam concrete, it does not split or blow, as it happens with heavy concrete. AS a result, armature is longer protected from heating. Tests show that foam concrete 150 mm wide can protect from fire for 4 hours. During tests carried out in Australia, an outer side of a foam concrete panel 150 mm wide was exposed to temperatures up to 1200^0C.

- **TRANSPORTATION**

Favorable combination of weight, volume and packaging makes all building constructions convenient for transportation and allow to use motor or railway transport

IV. RESULTS AND ANALYSIS

4.1 CEMENT AND FINE AGGREGATE TEST RESULTS:

Table 4.1

4.1.1 FINENESS MODULUS:

S.No	Sieve designation	Weight of retained (gms)	Cumulative weight retained (gms)	Cumulative weight retained (%)	% passing	Acceptance Limits (require as per IS 383-1979)			
						Zone-1	Zone-2	Zone-3	Zone-4
1.	10mm	0	0	0	100	100	100	100	100
2.	4.75mm	6	6	0.6	99.4	90-100	90-100	90-100	95-100
3.	2.36mm	17	23	2.3	97.7	60-95	75-100	85-100	95-100
4.	1.18mm	112	135	13.5	86.5	30-70	55-90	75-100	90-100
5.	600µ	358	493	49.3	50.7	15-34	35-59	60-79	80-100
6.	300µ	438	931	93.1	6.9	5-20	8-30	12-40	15-50
7.	150µ	64	995	99.5	0.5	0-10	0-10	0-10	0-15
8.	Pan	5	1000						

Fineness modulus=(cumulative % weight retained/100)=2.58

Table 4.2

4.1.2 BULKING OF SAND:

S.No	Height of sand taken(X)	Height of settled sand(Y)	Loss of height of sand(X-Y)	% of bulk age (X-Y/Y)*100
1.	200mm	180mm	20mm	11.11
Total				11.11

Table:4.3 cement and fine aggregates test results

Properties	Values

(A)Cement	
Grade Of Cement	53
Specific Gravity	3.15
Initial Setting Time	75 min
Final Setting Time	360 min
(B)Fine Aggregate	
Fineness Modulus	2.58
Specific Gravity	2.65

4.2 COMPRESSION TEST: (1MPa = 1N/mm^2)

Table4.4Trials: For Foam Concrete Mix – 1 (Containing Cement & Fine Aggregates)

S.No	Age Of Concrete	Cross Sectional Area(mm^2)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (MPa)
1.	7 days	22500	143	6.55	6.296
2.		22500	140	6.22	
3.		22500	142	6.11	
4.	14 days	22500	246	10.93	10.8
5.		22500	243	10.8	
6.		22500	240	10.66	
7.	28days	22500	340	15.11	15.230
8.		22500	345	15.33	
9.		22500	343	15.24	

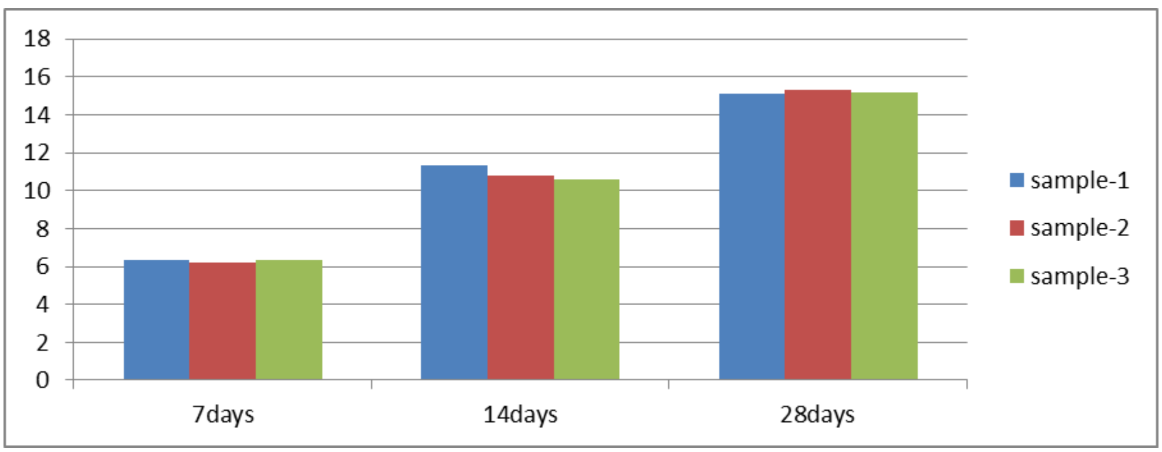


Fig:4.1 compression test trial:1

According to above graph there no variation in compressive strength. The time of curing will increases, the compressive strength also increases.

Table 4.5Trials: For Foam Concrete Mix – 2 (Containing Cement, Blast Furnace Slag & Fine Aggregates &Fly Ash)

S.No	Age Of Concrete	Cross Sectional Area(mm^2)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (MPa)
1.	7 days	22500	43	1.91	1.910
2.		22500	44	1.95	
3.		22500	42	1.86	
4.	14 days	22500	110	4.88	5.000
5.		22500	115	5.11	
6.		22500	113	5.02	
7.	28days	22500	200	8.9	9.0
8.		22500	205	9.11	
9.		22500	202	8.97	

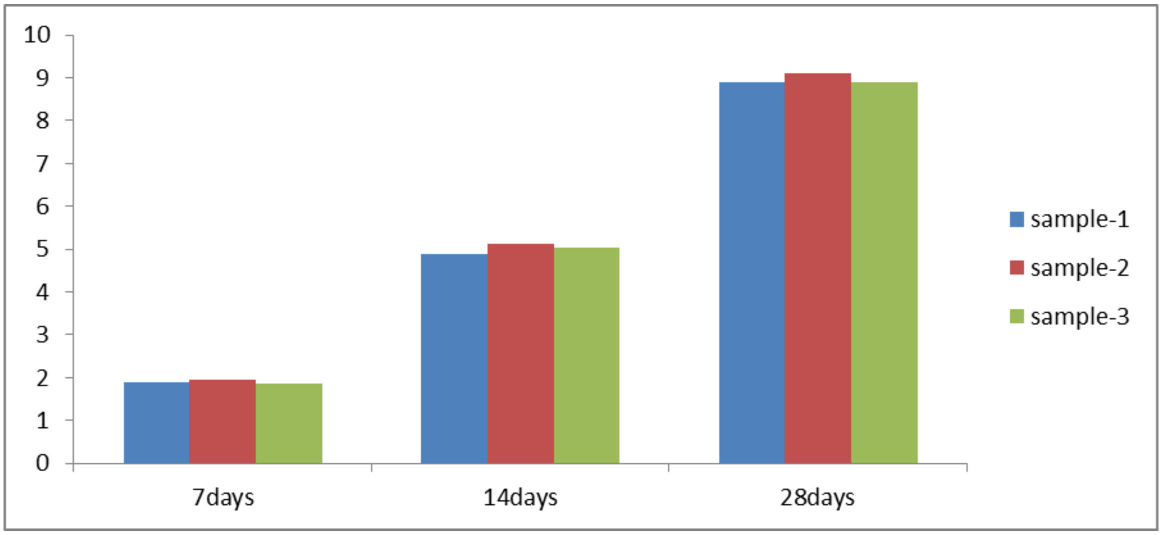


Fig :4.2 compression test trial:2

According to above graph it compared to trial-1 the compressive strength will be decreases 40%. Because of the amount of fly ash we mix in this proportion. The fly ash has low compressive strength.

4.6 Trials: For Foam Concrete Mix – 3 (Containing Cement, Blast Furnace Slag & Fine Aggregates& Glass Powder)

S.No	Age Of Concrete	Cross Sectional Area(mm^2)	Load (KN)	Compressive Strength (KN/mm^2)	Average Compressive Strength (MPa)
1.	7 days	22500	56	2.4	2.411
2.		22500	55	2.44	
3.		22500	52	2.31	
4.	14 days	22500	150	6.66	6.740
5.		22500	152	6.75	
6.		22500	153	6.8	
7.	28days	22500	255	11.33	11.332
8.		22500	254	11.28	
9.		22500	256	11.37	

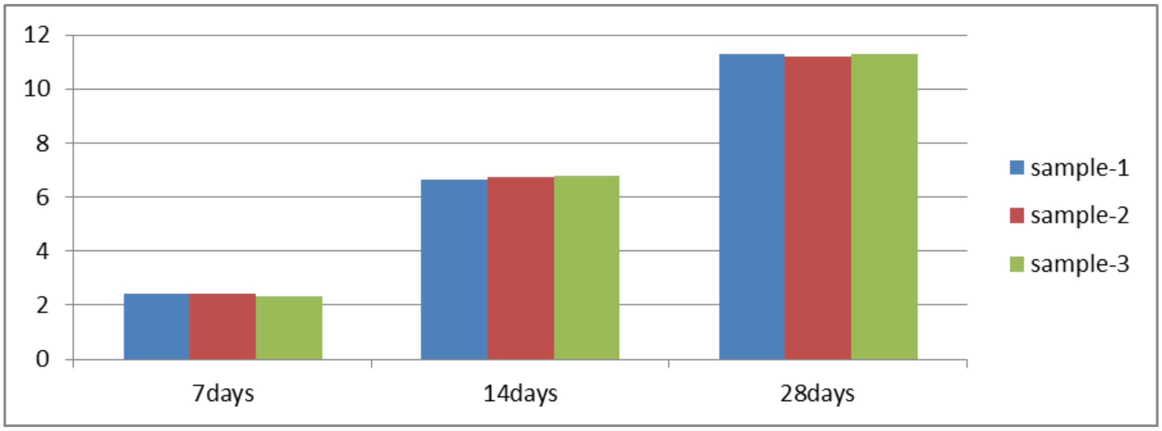


Fig:4.3 compression test trial-3

According to above graph the compressive strength will increases(25%) with compared to trial-2. Because we decrease fly ash content and added glass powder to the mix to increases compressive strength.

4.7 Compression test for bricks

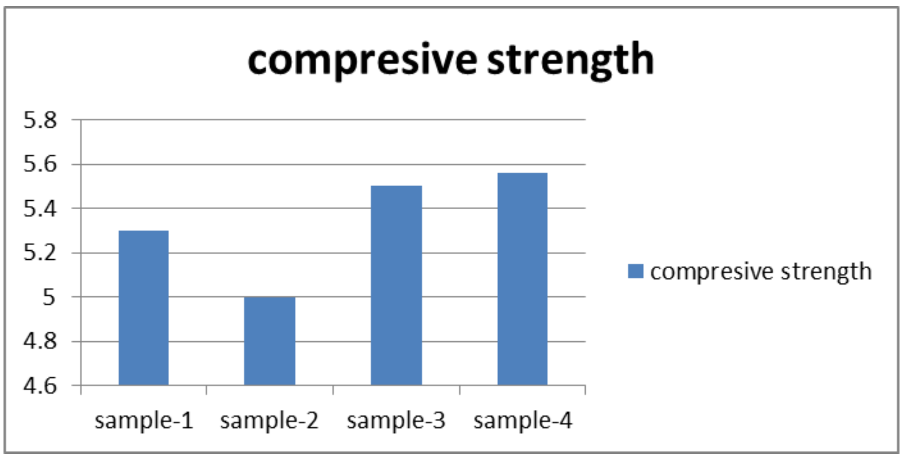


Fig:4.5Compressive Strength of Brick Specimens

The average experimental strength calculated experimentally is 5.328 MPa which goes in line with the compressive strength.

V. CONCLUSION

The density of foamed concrete is inversely proportional to the percentage of foam that is added to theslurry/mortar.

- The compressive strength and density of foam concrete increases with age.
- The compressive strength of foamed concrete increases with increase in the density.
- Fine aggregate had a beneficial effect on significantly increase in compressive strength of foamed concrete.
- De-moulding of higher density foamed concrete panels is possible after 24 hours but it requires minimum 3 daysfor lower density foamed concrete panels.
- The starting of strength gain for foamed concrete is on higher side than that of normal weight concrete andstrength gain beyond 28 days is faster than normal weight concrete.
- The addition of fly ash of equal amount of cement makes it possible to gain the target strength with age.

- This study has shown that the use of flay ash in foam concrete, can be greatly improves its properties.
- The mixed proportion for foamed concrete used in this research report cannot be used for structural purposebecause there 28 days compressive strength is less than 17 MPa.
- Improved structural efficiency in terms of strength to density ratio resulting load reduction on the structure andsubstructure.
- Strength to density ratio is much higher for foam concrete mix – 1 compared to mix – 2 & mix - 3 concrete.
- Both the foamed concrete mixed proportions can be used for making partition walls in buildings.

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