FOAM CONCRETE –THE PRESENT GENERATION’S BUILDING SOLUTION

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ABSTRACT

Cellular concrete is a solution in which coarse aggregates have been replaced altogether by air or gas in the form of tiny bubbles for drastic weight reductions. It is a lightweight material that excels in thermal insulation and fire-resistance. A significant characteristic of foam concrete is the ability to control its density over a wide range, and this is achievable by adding a calculated amount of foam to the base mix. Foam concrete has gained importance because of its wide range of applications which include Thermal insulation, Fire resistance, Workability, Flow-ability, Sound absorption, Self-compacting, Density, Energy absorption etc. Thus cellular concrete is a problem solver for wide variety of challenges in construction, mining and manufacturing applications.

KEYWORDS: Foam Concrete, Surfactants, Foaming Agent, Bubbles

INTRODUCTION

Foam concrete is defined as a cementitious material having a minimum of 20 percent (by volume) of mechanically entrained foam in the mortar slurry in which air-pores are entrapped in the matrix by means of a suitable foaming agent. The air-pores are initiated by agitating air with a foaming agent which is diluted with water. The foam then carefully mixes together with the cement slurry to form foam concrete. With proper control in dosage of foam and production methods, a wide range of densities starting from the least density of 400kg/m3, can be produced thus providing flexibility for various applications.

METHODS OF CELLULAR CONCRETE PRODUCTION

Though there are many proprietary production methods and agents used in cellular concrete production, they can be summarized in three broad categories:

- Methods dependent on the chemical reaction of a rising agent
- Methods dependent on mechanical beating
- A hybrid method, dependent on both mechanical beating of a preformed foam produced from smart foam liquid concentrate and a chemical reaction.

Methods dependent on the chemical reaction of a rising agent are best used for cellular concrete production in manufacturing and pre-casting plants. Methods dependent on mechanical beating are best used for cellular concrete production for on-site applications. The hybrid method can be used for cellular concrete production for on-site applications, in manufacturing and pre-casting plants.

CONSTITUENTS OF FOAM CONCRETE

Cement

Cement is used as the main binder for foam concrete. Foam concrete can be produced with all types of cements
and is less affected with changes in cement types. However, 53 Grade cement is generally preferred in the production process.

**Fly Ash**

Fly ash has been widely used in construction practices. A good fly ash should have high fineness, low carbon content and good reactivity which would enhance the technical advantage of the properties of foamed concrete. About seventy five thermal plants are distributed evenly across India, hence hauling cost is minimal.

**Water**

Water used in the manufacture of foam concrete is potable water free from suspended solids and other wastes.

**Surfactants (Foaming Agent)**

The surfactant is a key factor in the types of bubbles generated. Surfactants are wetting agents that lower the interfacial tension between two liquids and also lower the surface tension of liquid, allowing easier spreading. There are extensive varieties of surfactants (foaming agent) available in the market.

Surfactants 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. But it is very important to store all surfactants accordingly because they are inclined to deterioration at low temperatures. The surfactant solution consists of one part surfactant and between 5 to 20 parts water. But the optimum value is a function of the type of surfactant and the technique of production

Generally two types of surfactants can be used to produce foam:

- Protein based Surfactants and,
- Synthetic based Surfactants.

Protein-based surfactants are the original surfactants, produced from refined animal products such as hoof, horn and skin. They are relatively crude materials derived from hydrolysed animal carcass residues which are subjected to biodegradation. Protein-based surfactants produce foamed concrete with strength/density ratio of about 50% to 100% higher compared to synthetic surfactants (McGovern, 2000).

Synthetic based surfactants are produced using man-made chemicals such as the ones used in shampoos, soap powders and soaps. Dransfield (2000) stated that synthetic surfactants are stable, easy to formulate and consistent in performance. However, the bubble size is larger and the cells are more open due to higher expansion. Or it can be stated as Foams formed from protein based surfactants have smaller bubble size, are more stable and have a stronger closed bubble structure compared to the foam produced using synthetic surfactants. This results in foamed concrete of lower strengths compared to foamed concrete produced using protein-based surfactants.

**MICROSTRUCTURE OF BUBBLES**

The individual bubbles or cells in cellular concrete vary from microscopic size to the size of a sand grain. Microstructure refers to the microscopic description of the individual constituents of a material. Foamed concretes consist of air voids of approximately 0.1 to 1 mm in size, uniformly distributed in a matrix of fillers and cements (Wee et al., 2006). On a microscopic scale, the most important properties of foamed concrete are the air void shape, spacing factor and size distribution (Nambiar and Ramamurthy, 2007).
Bubbles produced from a protein surfactant are defined, not connected and closed cell. In contrast, bubbles produced using synthetic surfactants are more open, have ‘holes in hole’ and are undefined. Within the same surfactant type, the most significant finding was that density had the greatest effect on the bubbles sizes.

PHASES OF FOAM

Foam phases can be distinguished into two categories:

- Production of cement paste, foaming and processing
- Foam stability until hardening

During the first phase, method, requirements of air-entraining and workability are the determining factors for the specification of the cement paste and its properties. A quick stabilization of the interface between air and cement paste is essential. This can be managed by surfactants (air-entraining admixture or foaming agent) in high dosage.

In the second phase the focus is on foam stability. Therefore the separation of air and cement paste by bubble up or flow out has to be reduced to a minimum. This can be achieved by fine, fast cements which stop foam collapsing by rapid hardening.

PRODUCTION PROCESS OF FOAM CONCRETE

![Figure 1](image)

The compressed air, foaming agent and water are let into the foam generator. The combination of foaming solution and air is then forced through restrictions in the foam lance, where it expands and foam is created to the required density.

The base materials and the foam are fed into the mixer where all the components are mixed together. These mixers have the effect of blending foam and base materials together into a completely homogenized mix ensuring a repeatable process.

MATERIAL PROPERTIES OF FOAM CONCRETE

Density

The density of foam concrete is the volumetric function of foam that is added to the cement paste. When undertaking the design of foamed concrete mixture, a target casting density is determined using the dry density which is the most important factor affecting the properties of the mixture (Kearsley, 1997)

The relationship between dry density and casting density between 600 kg/m³ and 1200 kg/m³ can be calculated using the following linear equation (Kearsley and Mostert, 2005)

\[ \rho_m = 1.034 \rho_{dry} + 101.96 \]  

(1)
Where $\rho_m$ is the target casting density (kg/m$^3$) and $\rho_{dry}$ is the dry density (kg/m$^3$)

**Water Cement Ratio**

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. (Neveille, 1987). For foamed concrete, workability is not a major factor, but if adequate water is unavailable for the initial reaction of cement paste, the cement withdraws water from the foam, causing rapid degeneration of the foam. If excess of water is added, segregation takes place, causing variation in density (Kearsley, 1996). The reported Investigations point out the water cement ratio in the range of 0.4 to 0.8 for foam concrete.

**Relationship between Density and Compressive Strength**

According to Vine-Lott (in 1985), the compressive strength of foam concrete is an inverse function of the density of the material. This relationship between density and compressive strength is exponential, the value of exponent varying with size and distribution of air voids.

**CONCLUSIONS**

- Foams formed from protein based surfactants have smaller bubble size, are more stable and have a stronger closed bubble structure compared to the foam produced using synthetic surfactants. Hence, they are high strength foam concretes.
- The density of foam concrete is the function of volume of foam that is added to the cement paste.
- The compressive strength of foamed concrete is an inverse function of the density of the material.

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