

Various Effect of Foam Concrete Other Than Ordinary Concrete

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Abstract— In this paper the Foam concrete is a type of aerated lightweight concrete; foam concrete does not contain coarse aggregate and can be regarded as an aerated mortar. Foam concrete is produced when pre-formed foam is added to slurry, the function of foam is to create an air voids in cement-based slurry. Foam is generated separately by using foam generator; the foaming agent is diluted with water and aerated to create the foam. The cement paste or slurry set around the foam bubbles and when the foam being to degenerate, the paste has sufficient strength to maintain its shape around the air voids. The foam concrete mixture becomes too stiff with lower content, causing bubbles to break, whereas the mixtures becomes too thin to hold the bubbles with high water content, leading to the separation of bubbles from the mixture, water-cement (w/c) ratio usually ranges from 0.4–1.25. Foam concrete can be designed to have any density within the dry density range of 300–1850 kg/m³. In this investigation two foam concrete mixtures are produced with and without sand and attempts have been made for selecting the proportions of foam concrete mix for the target plastic density of 1900 kg/m³. 18 cube specimens are prepared and tested for mixtures, then their physical as well as specific structural properties were investigated, Specific Strength concrete and the results are reported.

Key words: Structural Properties, Specific Strength, Foam Concrete, Air Voids

I. INTRODUCTION

Foam concrete differs from conventional concrete in that the use of aggregates in the former is eliminated. A foam aeration agent is used to absorb humidity for as long as the product is exposed to the atmosphere, allowing the hydration process of the cement to progress in its ever-continuing strength development. The difference between foam concrete and normal concrete is the use of aggregate in the foam concrete is eliminated and been replaced by the homogeneous cells created by air in the form of small bubble which utilize a stable air cell structure rather than tradition aggregates. It can be categorized as cellular material because it contains a higher amount of pores. Based on its morphology, foam concrete can be easily known as cellular material and the behavior must be same as cellular solid behavior Foam concrete is produced when foam is added to cement-based slurry. The foaming agent is diluted with water and aerated to create the foam. The cement paste or slurry sets around the foam bubbles and when the foam being to degenerate, the paste has sufficient strength to maintain its shape around the voids. The quality of foamed concrete is depends on the quality of foam, so that the foam is very important factor for the foamed concrete.

II. LITERATURE REVIEW

Foamed concrete is not a particularly new material, its first patent and recorded use dates back to the early 1920s. According to Sach and Seifert (1999), limited scale production began in 1923 and, according to Arasteh (1988), in 1924 Linde described its production, properties and applications. The application of foamed concrete for construction works was not recognized until the late 1970s, when it began to be used in the Netherlands for filling voids and for ground engineering applications. Significant improvements in production methods and the quality of foaming agents over the last 15 years have lead to increased production and broadening of the range of applications. An extensive research program carried out in Holland helped promote foamed concrete as a building material.

III. FOAM CONCRETE PROPERTIES

A. Water Absorption

Due to its closed cellular structure the water absorption of foamed concrete is very low.

However, higher the air content, higher the water absorption. Generally, it is less than 5 percent by volume.

B. Strength

1) Compressive Strength

The compressive strength of foamed concrete is influenced by many factors such as density, age, moisture content, the physical and chemical characteristics of constituent materials and mix proportions.

For uniform quality, it is desirable to control the variations in the mix proportions, type of cement and sand or other fillers as well as the method of production. With the same materials and testing conditions, the compressive strength increases with the density. Compressive strength will continue to increase indefinitely due to the reaction with CO₂ present in the surrounding air. However, the increase in strength with age is virtually linear over the first 12 month, unlikely dense-weight concrete which levels out much earlier. The rate of development strength in foamed concrete is higher than that in the dense weight concrete, for products such as foamed-concrete building blocks and panels, it is desirable that curing process should assist in the moisture retention for longer periods. Steam curing is another option, if curing time is crucial.

2) Tensile Strength

Depending on the method of curing, the tensile strength of foamed concrete can be as higher as 0.25 times its compressive strength with and ultimate strain of about 0.1 percent.

3) Shear Strength

The shear strength generally varies between 6 and 10 percent of the compressive strength. Shear reinforcement may be required in flooring and roofing units.

4) Shrinkage

Like all cement products, foamed concrete shrinks during the setting stage. The shrinkage depends upon the type and amount of cement in mix; water-to-cement ratio, type of curing process, size of element, quantity of sand and density of foamed concrete. The most shrinkage occurs during the first 28 days, after and soundproofing screeds in multi-storey residential and commercial buildings. The concrete of this density range is also suitable for bulk-fill applications.

IV. METHODOLOGY OF FOAM CONCRETE

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.

- Determine the influence of the density and compressive strength of foamed concrete with and without sand.
- Compare the density and compressive strength of Foam Concrete with Normal Weight Concrete.
- Compare the Percentage Strength Gain of Foam Concrete over Normal Weight Concrete.
- Compare the Specific Strength (Strength-to-Density Ratio) of Foam Concrete with Normal Weight Concrete.

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.

V. MIX CONSTITUENT PROPORTIONS

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/m³ of the total mix water, depending on the concrete plastic density, early curing regime and subsequent exposure conditions. Assuming a given target plastic density (D, kg/m³), water/cement ratio (w/c) and cement content (c, kg/m³), the total mix water (W, kg/m³) and fine aggregate content (f, kg/m³) are calculated from equations (1) and (2) as follows.

$$\text{Target plastic density, } D = c + W + f \quad (1)$$

Where $c = \text{PC} + \text{FA fine}$,

$f = \text{FA coarse} + \text{sand}$

Free water content,

$$W = (w/c) \times (\text{PC} + \text{FA fine} + \text{FA coarse}) \quad (2)$$

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 $\pm 50 \text{ kg/m}^3$ 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 20°C 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

VI. COMPOSITION OF FOAM CONCRETE

This study is only concerned with aerated foam concrete which is produced by introducing air voids into the cement based slurry. The cement slurry consists of cement, sand, fly ash and water. Depending on the required properties it can be produced with or without lightweight aggregate such as sand, fly ash etc. 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

A. Constituent Materials

The foamed concrete has been produced by using the following constituents' viz. cementitious material (i.e. cement & fly ash), sand, water and foaming agent.

Cementitious Material-Portland cement is preferred over other cements, such as pozzolan. For early stripping and optimum mechanical properties, high-grade (early strength) cement is recommended. Thick walls and when using battery-moulds, excess heat is developing within and might therefore ask for a lesser grade of cement. The slower, hardening and better the final quality of concrete. Where economical, fly ash may be added to the mix to substitute some of the cement. Fly ash normally will retard hardening though. In this investigation 53 grade Ordinary Portland cement and Fine Fly ash has been used.

Sand-Optimum properties are achieved when selecting the most suitable raw material. The sand is mostly preferred from river, which is washed and should be with minimum 20% fines. Dust in sand increases the demand for water and cement, without adding to the properties, it also increases shrinkage. A certain, small amount of fines contributes towards strength. As in conventional concrete, the sand should be free of organic material or other impurities. Crushed sand, due to sharp edges may destroy the foam mechanically. In this investigation, locally available river bed sand has been used.

Water-Mixing water for concrete should be clean and free from injurious amounts of oils, acids, alkalis, salts, organic matter, or other potentially deleterious substances. When water is used to produce foam, it has to be potable and

for best performance, it should not exceed 25°C. Under no circumstances must the foaming agent be brought in contact with any oil, fat, chemical or other material that might harm its function (Oil has an influence on the surface-tension of water). The oil/wax used in moulds will not harm, since the foam by then will be embedded in mortar. Water to prepare the mix has to conform to general requirements for concrete.

Foam & Foaming Agent-Foam is a dispersion of a gas in liquid or in solid. Foam is produced by distribution of gas in a liquid under the influence of a foaming medium, such as soap, oil, acid or a wetting agent. During the production small bubbles are formed and are separated from liquid by a membrane. Clearly, there are many different types of foams with various applications.

B. Experimental Study on Foam Concrete

1) Samples

- Food industry
- Soap industry
- Industry of insulating materials
- Fire protection industry
- Industry for backfilling materials

The density of the foamed concrete is a function of the volume of foam that is added to the cement paste.

To ensure that the desired percentage air is entrained in the mixture, pre-foaming; where the foaming agent is aerated being added to the mixture is used. The aerated foaming agent, on mixing with the cement based slurry entrains a controlled quality of air in uniformly dispersed discrete cavities. These voids are typically spherical.

The containments holding foaming agent must be kept airtight and under temperatures not exceeding 25°C.

This way the shelf life is guaranteed for 24 months from date of Invoice. Once diluted in 40 parts of potable water, the emulsion must be used soonest.

Depending on an application using foam produced from a surfactant usually is not an environmental issue.

However in some countries this can be a religious concern/significance. This would be the case when using hydrolyzed protein based surfactants that contain keratin or casein derivatives.

Surfactants are surface-active substance or agent [detergents, wetting agents, emulsifiers] that when added to water lowers surface tension and increases the "wetting" capabilities of the water, thus improving the process of wetting and penetrating that surface or material. When agitated forms a large mass of micro/macroscopic bubbles. With this device or process a surfactant [wetting agent] or foam concentrate is diluted with water to form a foam solution. This solution is then injected with compressed air through a blending device or foam generator and the foam is produced from foam generator.

Mix Design-There is no standard method for proportioning foamed concrete (i.e. mix design), but it is a specified target plastic density that becomes a prime design criterion. On the basis of target plastic density a theoretical mix design is to be formulated and site trials are undertaken and the results from the site trials are used as mix design for the foamed concrete. A tolerance on plastic density was considered about 100 kg/m³ of the target plastic density.

Assuming a target plastic density of 1900 kg/m³ Since the foam concrete is in slurry form higher water-cement ratio is required so assuming W/C is 0.60

Mixing Procedure-Initially the constituent materials were weighed and dry mixing was carried out for cement, fly ash and sand. This was thoroughly mixed in concrete mixer and then the water was added incrementally to obtain a reasonable working mix. The mixing was carried out for one minute duration. The required quantity of foam was set in foam generator and then it was added to the wet mix and again the mixing was continued. Mixing for more duration after adding foam will disintegrate the foam. Then they were poured into the cube moulds of size 150x150x150 mm.

VII. EXPERIMENTAL STUDY

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.

Composition 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/m³, 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 foam generator the out-put of generator is 30-32 lit/min. for producing the foam foaming agent has been used, foaming agent is diluted with water in a ratio of 1:40 and then aerated to a density of 74 kg/m³.

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.

Compressive Strength-The 150 mm test cubes were cast in steel mould and de-moulded after \pm 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 3, 7 and 28 days.

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 3, 7 and 28 days. The density was again measured at the time of determination of compressive strength this density is known as test density

VIII. RESULTS

In this heading, discussion will be focused on the performance of foamed lightweight concrete. All the tests adopted were described in the previous chapter. The results presented in this chapter are regarding the compressive strength test and density for both mixtures of the foamed lightweight concrete. Two foam concrete mixtures with and without sand for a target plastic density of 1900 kg/m³ are used in this investigation. 24 cubes were prepared for mix - 1 (i.e. cement-fly ash mixture) and 24 cubes were prepared for mix -2 (i.e. cement-fly ash-sand mixture) After 3, 7 and 28 days a set of three cubes were crushed on Compression testing machine and before crushing cubes were weighed for calculating their test density. The cube specimens were surface dried at the time of testing.

Experimental Result for Compressive Strength and Density

Cement: sand=1:1

Weight of sand=2.7kg

Weight of cement=2.7kg

Total amount of cement sand=5.4kg

Water is 8%of total weight

Foam added=800gm

Density=1600kg/m³

Slump test slump value of foam concrete is measured how much the paste spread when water is added in paste. Spreading of paste increase with increase in water. In this two values are obtain foam concrete paste with water and without water

A. Result Obtained for Sample

Slump spread in mm (cement +sand +foam)	140	140	140
Water content	8%	10%	12%
Slump spread in mm (cement +sand +foam +water)	165	180	190

Table 1:

– Result obtained by air curing method

1) 7 days = 135kN

2) 14 days = 175kN

3) 28 days = 220kN

– Compressive strength

1) 7 days = 6N/mm²

2) 14 days = 7.76Nmm²

3) 28 days = 9.76Nmm²

1) Result Obtained by Water Curing Method

– Load that sample hold

1) 7 days = 100kN

2) 14 days = 130kN

3) 28 days = 145kN

– Compressive strength

1) 7 days = 4.45N/mm²

2) 14 days = 5.7Nmm²

3) 28 days = 6.4Nmm²

2) Result Obtained by Air+ Water Curing Method

– Load that sample hold

1) 7 days = 135kN

2) 14 days = 160kN

3) 28 days = 195kN

– Compressive strength

1) 7 days = 6N/mm²

2) 14 days = 7.12Nmm²

3) 28 days = 8.45Nmm²

IX. COMPARISON

The density of foam concrete (300 to 1850 kg/m³) is very low when compared to conventional concrete(2200 to 2600 kg/m³), therefore, the self-weight of a structure built with foamed concrete would undoubtedly be reduced significantly, leading to tremendous savings in the use of reinforcement steel in the foundations and structural members. Use of lightweight concrete as an alternative to normal concrete in construction can decrease the building's dead load as well as the force exerted on the structure due to earthquake excitations and the resultant collapse weight of the building if it falls down.

X. CONCLUSIONS

- Result shows that compressive strength of sample using air curing have gained a higher strength compared to samples that use water curing method
- The Density of Foamed Concrete is inversely proportional to the percentage of foam that is added to the Slurry / mortar.
- The slump spread of fresh foam concrete from the test performed is affected by water content
- 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.

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