TO EXPERIMENTAL STUDY AND COMPARISON BETWEEN CONCRETE & FOAM CONCRETE

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ABSTRACT-Foam concrete is a type of aerated lightweight concrete; foam concrete does not contain coarse aggregate and canbe 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 (Density) as well as specific structural (Compressive Strength) properties were investigated, Specific Strength and Percentage Strength gain for foamed concrete is compared with normal weight concrete and the results are reported
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Index term: Foam Concrete, Light Weight Concrete, Density, Strength, Specific Strength

INTRODUCTION

Foam concrete17 is a mixture of cement, fine sand, water and special foam which once hardened results in a strong, lightweight concrete containing millions of evenly distributed, consistently sized air bubbles or cells. The density of FC is determined by the amount of foam added to the basic cement and sand mixture. Foam concrete is both fire and water resistant. It possesses high (impact and air-borne) sound and thermal insulation properties. Foam concrete is similar to conventional concrete as it uses the same ingredients. However, 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 between3 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 behaviorFoam 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. To ensure that the desired percentage of air is entrained in the mixture pre-foaming, where the foaming agent is aerated before being added to the mixture, is recommended

.**History and Background-**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 1924Linde 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.

PROPERTIES OF LIGHTWEIGHT FOAM CONCRETE

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.

Strength

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 CO_2 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 thanthat in the dense weight concrete, for products such as foamed-concrete building blocks and panels, it is desirable thatcuring process should assist in the moisture retention for longer periods. Steam curing is another option, if curing time iscrucial.

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.

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.

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 sandand density of foamed concrete. The most shrinkage occurs during the first 28 days, after and soundproofing screeds inmulti-storey residential and commercial buildings. The concrete of this density range is also suitable for bulk-fillapplications.

OBJECTIVE OF STUDY AND STUDY 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.

Experimental Study on Foam Concrete

The objective of this study is to:
- 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 thetests are performed in college laboratory.

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 primedesign criterion. It should be noted that it is difficult to design for a specific dry density, as foamed concrete will desorpbetween 50 and 200 kg/m^3 of the total mix water, depending on the concrete plastic density, early curing regime andsubsequent exposure conditions. Assuming a given target plastic density (D, kg/m^3), water/cement ratio (w/c) and cementcontent (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, $D = c + W + f$ (1)

Where $c = PC + FA_{fine}$,
$f = FA_{coarse} + sand$
Free water content,
$W = (w/c) X (PC + FA_{fine} + FA_{coarse})$ (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 BSEN 12350-611 by weighing a foamed concrete sample in a pre-weighed container of a known volume. A tolerance onplastic density was set at ± 50 kg/m$_3$ of the target value, which is typical of industry practice for foamed concreteproduction. The specimens were then cast in steel moulds lined with domestic plastic 'cling' film, as foamed concrete wasfound 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$_o$C until testing.

It is recognized that sealed-curing may result in specimens having different degrees of pore saturation. This effect wasconsidered to be minor for the range of constituent materials studied and certainly more representative of the actualproperties of the material than would be the case if standard curing was applied. Again, sealed-curing reflects typicalindustry practice for foamed concrete

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COMPOSITION AND PROPERTIES OF FOAM CONCRETE

This study is only concerned with aerated foam concrete which is produce 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 itcan be produced with or without lightweight aggregate such as sand, fly ash etc. The introduction of air voids is achievedby adding pre-formed foam to the mixture. A foaming agent is diluted with water and aerated to form the foam

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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.

Cementations Material-Portland cement is preferred over other cements, such as pozzolan. For early stripping and optimum mechanicalproperties, high-grade (early strength) cement is recommended. Thick walls and when using battery-moulds, excess heat isdeveloping within and might therefore ask for a lesser grade of cement. The slower, hardening and better the final qualityof concrete. Where economical, fly ash may be added to the mix to substitute some of the cement. Fly ash normally willretard 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 andcement, without adding to the properties, it also increases shrinkage. A certain, small amount of fines contributes towardsstrength. As in conventional concrete, the sand should be free of organic material or other impurities. Crushed sand, due tosharp edges may destroy the foam mechanically. In this investigation, locally available river bed sand has been used.

Water-Mixing water33 for concrete should be clean and free from injurious amounts of oils, acids, alkalies, salts, organicmatter, or other potentially deleterious substances. When water is used to produce foam, it has to be potable and for bestperformance, it should not exceed 25°C. Under no circumstances must the foaming agent be brought in contact with anyoil, 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 embedded in mortar. Water to prepare the mix hasto 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 theinfluence of a foaming medium, such as soap, oil, acid or a wetting agent. During the production small bubbles are formedand are separated from liquid by a membrane. Clearly, there are many different types of foams with various applications.

Experimental Study on Foam Concrete

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 controlledquality of air in uniformly dispersed discreet 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, theemulsion 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 hydrolyzedprotein 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 wettingand penetrating that surface or material. When agitated forms a large mass of micro/macroscopic bubbles. With this deviceor process a surfactant [wetting agent] or foam concentrate is diluted with water to form a foam solution. This solution isthen injected with compressed air through a blending device or foam generator and the foam is produced from foamgenerator.
Mix Design-There is no standard method for proportioning foamed concrete (i.e. mix design), but it is a specified target plasticdensity that becomes a prime design criterion. On the basis of target plastic density a theoretical mix design is to beformulated 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/m3Since 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 workingmix. The mixing was carried out for one minute duration. The required quantity of foam was set in foam generator andthen it was added to the wet mix and again the mixing was continued. Mixing for more duration after adding foam willdisintegrate the foam. Then they were poured into the cube moulds of size 150x150x150 mm.

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.

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 (P_{60}) IS certifiedhaving 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-putof generator is 30-32 lit/min. for producing the foam foaming agent has been used, foaming agent is diluted with water in aratio 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 conventionalconcrete. It is essential, as in conventional concrete, that cement-based elements have moisture for hydration at an earlyage. This is particularly true in the presence of direct sunlight that is known to cause rapid dehydration of concretesurfaces; curing compound can be applied as an alternative barrier. Full time continuous curing has been done in thelaboratory.

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 aconstant 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 foamedconcrete 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 offoamed 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 measuredat the time of determination of compressive strength this density is known as test density

.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 andwithout 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 28days a set of three cubes were crushed on

Compression testing machine and before crushing cubes were weighed forcalculating 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

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

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

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

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

DISCUSSIONS-The density of foam concrete (300 to 1850 kg/m^3) is very low when compared to conventional concrete(2200 to 2600 kg/m^3), therefore, the self weight of a structure built with foamed concrete would undoubtedly be reducedsignificantly, 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 deadload as well as the force exerted on the structure due to earthquake excitations and the resultant collapse weight of thebuilding if it falls down.

CONCLUSIONS

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

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