Experimental Investigation on Lightweight Cellular Concrete

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Abstract— The usage of Cellular Light-weight Concrete gives a prospective solution to building construction industry. In this paper, an attempt is made to study on cellular lightweight concrete, and recommend as it can be used in construction industry. Lightweight foamed concrete is recently acceptable for use in low strength capacity for building and civil construction purposes as a result of its peculiar features such as low thermal conductivity, low self-weight and self-compacting features hence its high workability. It does not contain coarse aggregate and can be regarded as an aerated mortar. The main objective of this work is to study the Compressive strength and Split tensile strength of the concrete by various combinations of fine aggregate, fly ash and foam at the ages of 7 and 28 days.

Keywords: Light weight, cellular concrete, fly ash

I. Introduction

Foam concrete 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. Light weight foamed concrete has become more popular in recent years owing to the tremendous advantages it offers over the conventional concrete. Modern technology and a better understanding of the concrete have also helped much in the promotion and use of light weight foamed concrete. This chapter describes the nature of foamed concrete, its composition and properties and how it use in civil engineering works. Because the properties of foamed concrete can vary widely, and it can be used in a wide variety of requirements for each case.

II. Properties

A. *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. Therefore, there are many different industries, which use foam-like products. 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 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, 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.

B. *Fly ash*

Ordinary class F fly ash of cementitious property collected from the nearer thermal power plant of specific gravity 2.31 is taken. The quality parameters of fly ash for use in concrete confirming to IS: 3812 (part 1) has been used.

III. Experimental Study

The experimental study consists of casting of cube and cylinder specimens. The dimensions of cube 150mm x 150 mm x 150mm. The dimensions of cylinder are 150mm x 300 mm. All specimens had the same geometrical dimensions. Experimental data on load, method of each of the specimens are acquired. The change in load moving capability and failure mode of the specimens are investigated for different types of mix ratios.

A. *Casting of Specimen*

For conducting experiment, the quantity of 1:2 is taken for cement, fine aggregate and 1:2 for fly ash, fine aggregate. The mixing is done by using concrete mixture. The cubes and cylinders are cured for 28 days. Compressive tests and split tensile tests on shaped concrete (150 × 150 × 150 mm concrete cube and 150 x 300 mm cylinder) were performed and the average concrete compressive strength (fcu) after 28 days for each specimen.

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Fig. 1(a): Specimen Casting (Cube)

Fig. 1(b): Specimen Casting (Cylinder)

B. Specimen Testing

1) Compression Strength Test

The cube specimens were placed in compression testing machine and the load is to be applied without shock and increased continuously at a rate of approximately 140 kg/cm2 minimum until the resistance of the specimen to be increasing load breaks down and no greater load can be restrained. The maximum load applied to the specimen is to be recorded and the appearance of the concrete and any unusual features in the types of failures is noted. The measured compressive strength of the specimen is to be calculated by dividing the maximum applied load to the specimen during the test by the cross sectional area.

$$Compressive\ strength\ (MPa) = \frac{Maximum\ Load\ (N)}{Cross\ Sectional\ Area\ (mm^2)} = \frac{P}{A}$$

Where,
P = Failure of the specimen
A = Area of specimen

Fig. 2: Compression Testing of Specimen

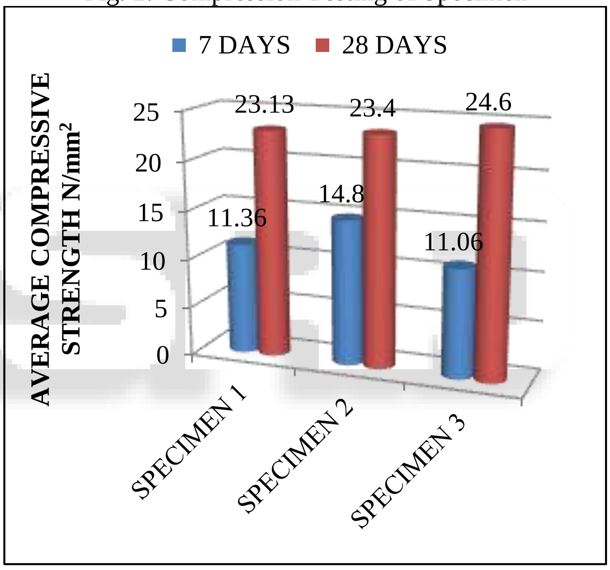

Fig. 3: Average Compressive Strength of Conventional Concrete

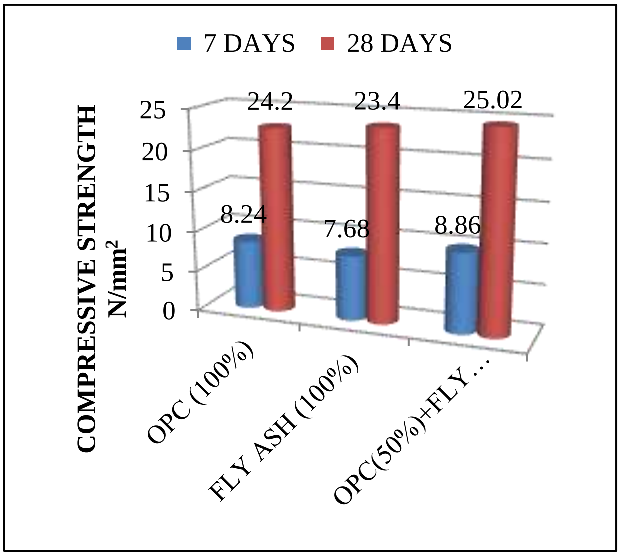

Fig. 4: Average Compressive Strength of Foamed Concrete

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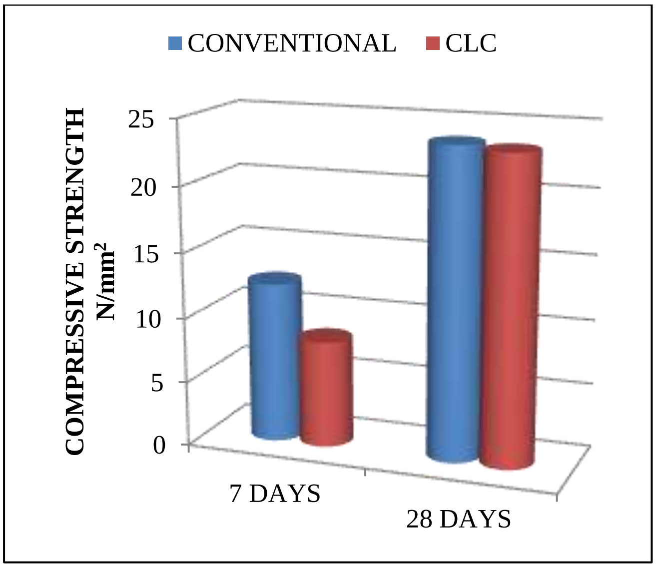

Fig. 5: Comparision of Compressive Strength Result of Foamed and Conventional Concrete

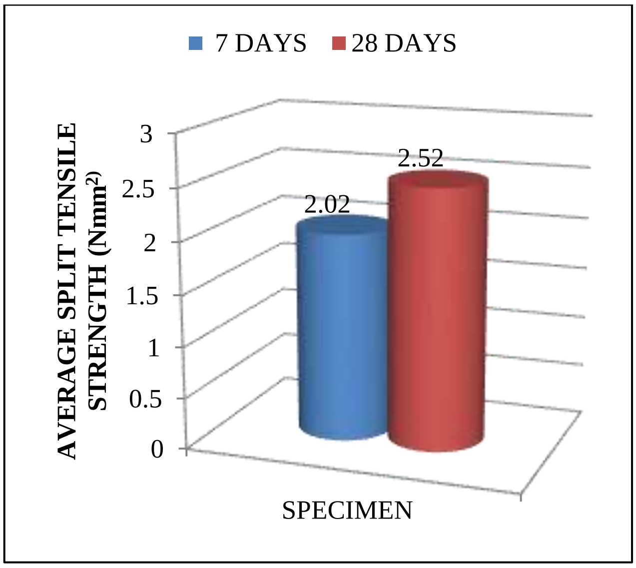

Fig. 7: Average Split Tensile Strength of Conventional Concrete

2) *Split Tensile Strength Test*

The cylinder specimen is placed horizontally between the loading surface of the compression testing machine and the load is applied until the failure of the cylinder, along the vertical diameter. Narrow packing strips of suitable materials such as plywood are placed between the specimens and loading plates of the testing machine the packing strip is soft enough to allow distribution of the load over a reasonable area to prevent large contract area. Then the load is applied until the failure of the cylinder, along the vertical diameter. The failure load of tensile strength of cylinder is calculated by using the formula.

$$Tensile\ Strength = \frac{2P}{\pi DL}$$

Where,

P = Failure of the specimen

D = diameter of the specimen

L = Length of the specimen

Fig. 6: Split Tensile Testing Machine

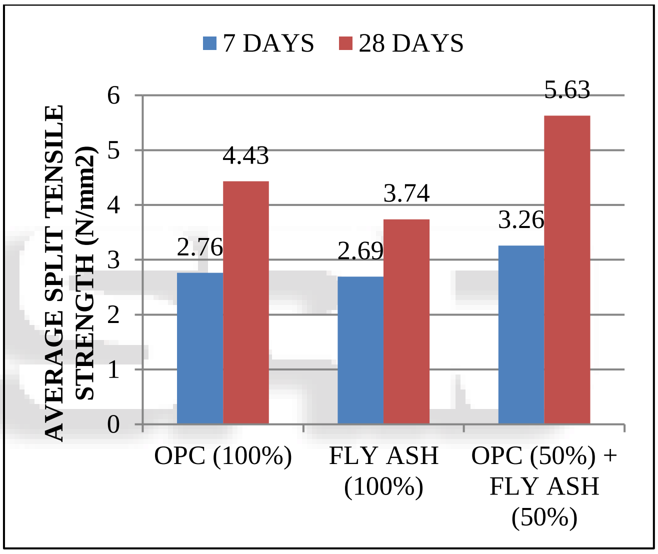

Fig. 8: Average Split Tensile Strength of Foamed Concrete

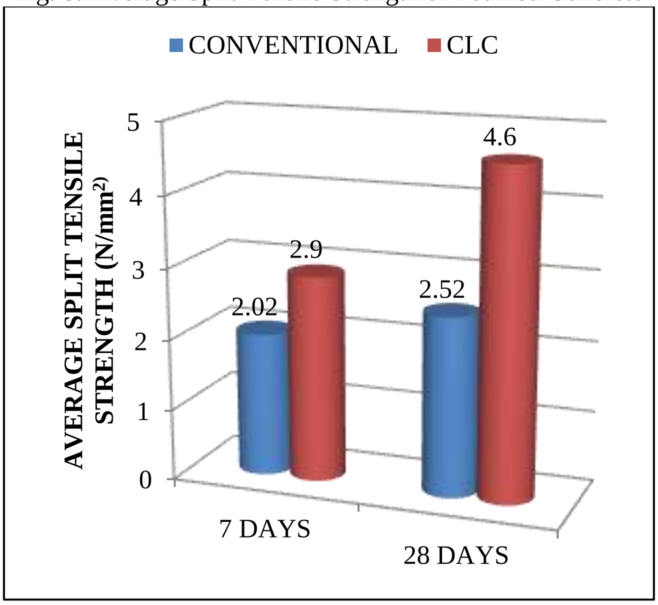

Fig. 9: Comparision of Split Tensile Strength Result of Foamed and Conventional Concrete

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IV. Conclusion

The result of this experimental study of sustainable lightweight foamed concrete production with various volume of fly ash as substitute of cement reveals the following.

- The foamed concrete was manufactured by using 50% of Fly ash and 50% of OPC gives a gainable compressive strength when compared to other mix ratios with an average compressive strength of 8.86 N/mm2 for 7 days and 24.13 N/mm2 for 28 days.
- That the production of sustainable concrete is possible with the substitution of the volume of hydraulic cements hence reduce carbon dioxide emission.
- The strength attained in foamed concrete does not depends upon coarse aggregate which intern highly reduces the cost of construction.
- The Compressive strength was also reducing relatively to the volume of fly ash and OPC present in the samples. The higher the individual (OPC/FLYASH) volume, the lower is its compressive strength.

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