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Sustainable Construction With Foam Concrete As A Green Green Building Material

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Abstract — A green building is an environmentally sustainable building, designed, constructed and operated to minimise the total environmental impacts. Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. It is claimed that 5% of the world's carbon dioxide emission is attributed to cement industry, which is the vital constituent of concrete. Due to the significant contribution to the environmental pollution, there is a need for finding an optimal solution along with satisfying the civil construction needs. Apart from normal concrete bricks, a clay brick, Foam concrete is a new innovative technology for sustainable building and civil construction which fulfills the criteria of being a Green Material. This paper concludes that Foam Concrete can be an effective sustainable material for construction and also focuses on the cost effectiveness in using Foam Concrete as a building material in replacement with Clay Brick or other bricks.

Keywords - Foam concrete, sustainable construction, Aluminium powder, LWC (lightweight concrete), AAC (Autoclave Aerated concrete).

I. INTRODUCTION

The most commonly used material in the building and civil engineering construction today is concrete. Ordinary concrete contains approximately 12% of cement. It has to be born in mind that cement industry alone contributes to 5% of the whole global emission of carbon dioxide for its yearly production, concrete being a part if cement industry has a share in that 5%. Also Construction as well as demolition debris constitute a considerable fraction of solid waste. There is great impact of the natural aggregate production on the quality of both groundwater and running surface water. Even then, Concrete has its extreme importance in the construction field. Thus the importance of reducing carbon dioxide emission has gained instantaneous importance and there by Sustainable Construction has gained high priority in the recent construction era [1].

II. SUSTAINABLE CONSTRUCTION

Sustainable construction aims at reducing the environmental impact of a structure over its entire lifetime, while optimizing its economic viability and the comfort and safety of its occupants. The principles of Sustainable Construction apply to the entire life cycle of construction, from planning to disposal.

A. ***Reduce resource consumption (Reduce)*** – Foam Concrete consumes a comparatively small amount of raw material relative to the amount of finished product produced.

B. ***Re-use Resources (Re-use)*** – Recent advancements in construction field are making use of recycled foam concrete to replace sand in the insulation layers.

C. ***Use recyclable resources (Recycle)*** – In India total production of fly ash are nearly as much as that of cement. But our utilization of fly ash is only 5% of the production. Foam concrete production consists of the recycled material fly ash (a by-product of thermal power plants).

D. ***Protect Nature (Nature)*** – The disposal of fly ash has become a problem and is a serious environmental problem which can be brought down with the production of Foam concrete blocks.

Besides, the manufacturing of Foam concrete produces no pollution and thus protects nature, fly ash as such & fly ash based alumino silicates shall also be tested.

E. ***Eliminate Toxics (Toxics)*** - It does not emit toxic gases even when exposed to fire and also its manufacture process is non-toxic.

F. ***Apply Life-cycle Costing (Economics)*** – Proves it self to be cost effective starting from the construction stage till the operating and maintenance costs.

G. ***Focus on Quality (Quality)*** – Along with maintaining low density due to the usage of foaming agent, Foam concrete satisfies the strength criteria. Lightweight concrete at its lightest density is stable and strong [1].

III. FOAM CONCRETE

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 Foam Concrete is determined by the amount of foam added to the basic cement and sand mixture. Foam concrete is both fire and water resistant. In some cases sand is replaced with quarry dust. 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 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.

Lightweight/foam concrete can be defined as a type of concrete which includes an expanding agent in it that increases the volume of the mixture while reducing the dead weight. It is lighter than the conventional concrete with a dry density of 300 kg/m^3 to 1840 kg/m^3.The main specialties of foam concrete are its low density and low thermal conductivity. There are many types of lightweight concrete which can be produced either by using lightweight aggregate or by using an air entraining agent. In this paper, aluminium powder has been used as an air entraining agent of concrete. The fine powder of Aluminium to the slurry reacts with the calcium hydroxide producing hydrogen gas. This hydrogen gas in the slurry mix gives the cellular structure and makes the concrete lighter than the conventional concrete that's why it is called as foam concrete or light weight concrete [5].

IV. EFFECT OF ALUMINIUM POWDER ON CONCRETE

Aluminium is used as a foaming agent in AAC production worldwide and it is widely proven as the best solution for its purpose. When aluminium is added (usually at about 0.2% to 0.5% by dry weight of cement) to the mixing ingredients, it reacts with hydroxide of calcium or alkali which liberates hydrogen gas ($3H_2$) and forms bubbles. The speed at which the air bubbles form is critical to the success of the final aerated concrete product.

$$2Al + 3Ca(OH)_2 + 6H_2O \rightarrow 3CaO \times Al_2O_3 \times 6H_2O + 3H_2$$

Aluminium is available in various forms. For the AAC industry the most used forms are powder and paste. Either one of these has its specific advantages and disadvantages regarding the production of autoclaved aerated concrete.

Mix proportions adopted

The economical mixes found by no. of trials at laboratory this mix is used for testing

Table 1: Compressive Strength for Specimens Made Of Sand

Sr. No.	Mix Proportions	Water / Cement Ratio	Aluminium Powder %	Ultimate Strength N/mm^2	
				7-Days	28-Days
1	1:6	0.6	0.0	20.02	23.02
			0.2	7.72	9.82
			0.4	3.97	4.14
			0.6	3.29	3.23

Table 2: Compressive Strength for Specimens Made Of Quarry Dust

Sr. No.	Mix Proportions	Water / Cement Ratio	Aluminium Powder %	Ultimate Strength N/mm^2	
				7-Days	28-Days
1	1:6	0.6	0.0	19.55	27.42
			0.2	6.13	6.40
			0.4	4.35	4.84
			0.6	3.32	4.44

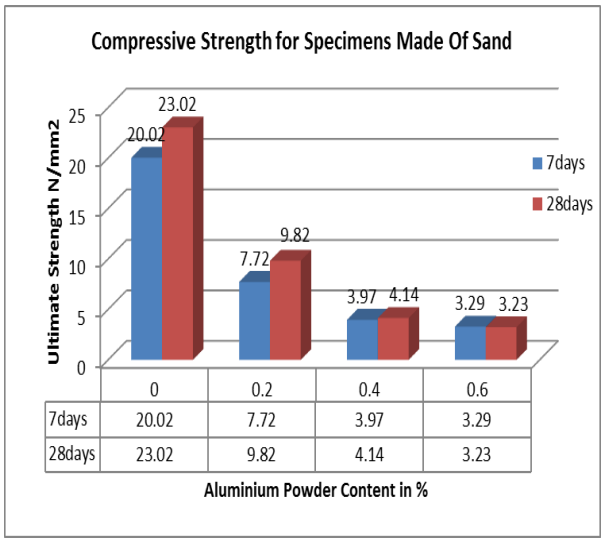

Fig 1: Compressive strength for sand

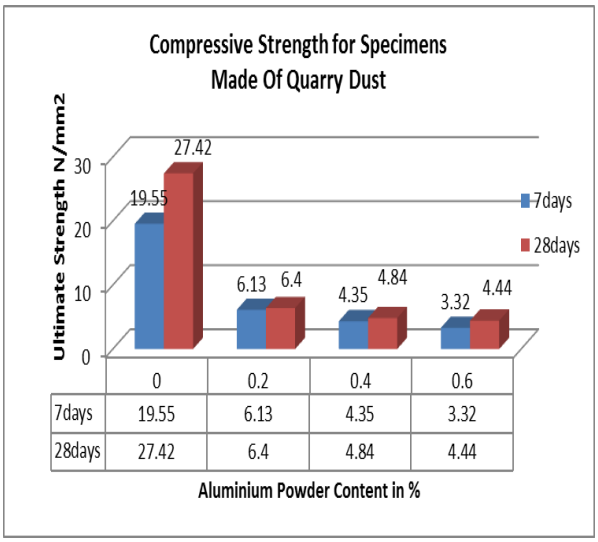

Fig 2: Compressive strength for Quarry dust

V. Characteristics And Properties Of Foam Concrete And Products

A. ***Flowability****:* The flowability of foamed concrete is characterized by the fact that it is self-compacting, free flowing and pumpable in the plastic state. The fact that it is pumpable makes it to be useful in inaccessible areas.

B. ***Workability:*** It can be cut with hand saw to desired dimension including angles and other shapes. It can also be drilled into, nailed into, grooved, routed, shaped, curved, coated, etc. and finished with paint, tile, plaster or veneer.

C. ***Thermal Insulation****:* It has high thermal capacity, or ability to absorb and retain relatively large amounts of heat energy. The effects are to minimize heat loss during cold weather and maximize heat gain during warm weather.

D. ***Sound Insulation****:* Because of its independent air cells, which dampen sound transmission, aerated concrete has excellent and sound insulation and absorption capacities. This has made it most suitable for construction of Hotels, entertaining facilities, multi-user apartment's freeway sound walls, and in buildings that require acoustic ability.

E. ***Fire resistance****:* Aerated concrete has a melting point of over 1500^{o}C, and provides approximately twice the fire resistance of normal concrete.

F. ***Wide range of densities****:* Aerated concrete can be produced to have a wide range of densities (300-1950 kg/m^3), with proper control in the dosage of the foam, materials selection and materials composition [4].

VI. CONCLUSION

The greatest challenge of 21st century is pollution-free environment for which foam concrete is one of the solutions in terms of construction industry. Substitution of recycled materials like fly ash with cement in the production of foam concrete reduces the emission of carbon dioxide into the environment without compromising the purpose, performance besides being cost effective. Due to its relatively low consumption of readily available raw materials, excellent durability, energy efficiency, innovative technology and relative cost effectiveness, Foam Concrete deserves to be said as sustainable concrete. Characteristics and properties of foamed concrete makes it unique, it has various application which are used in now a days construction techniques for various purposes.

1) In 1:6 mix proportions, quarry dust mix gives more compressive strength than the sand mix from table1 & table2.
2) The use of aluminium powder decreases the dead weight and the strength of the concrete as compared to normal concrete from the result shown in table 1 & 2.
3) The ultimate strength of Foam concrete is of the range between 3N/mm^2 – 23.5N/mm^2 for sand mixes and 4.25N/mm^2 – 27.42N/mm^{2}for quarry dust mixes with different aluminium content as shown in fig 1 & 2.
4) Compressive strength decreases as amount of aluminium powder is increased as observed in results.

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