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LIGHT WEIGHT FOAMED CONCRETE AS A SUBSTITUTE FOR BRICKS IN FRAMED STRUCTURES

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Abstract— Construction industries in India are extensively using various materials such as concrete block, bricks, hollow blocks, etc for infill walls and partition walls. These blocks are bulk in weight and have transportation problems. This study aims at the feasibility of cellular lightweight concrete using fly ash, cement and synthetic based foaming agent with density 800kg/m3. Mix design was prepared with cement to fly ash ratio as 1:1, 1:2,2:1 , followed by water curing. Experimental investigation was conducted on optimized mix with respect to density, compressive strength, water absorption, fire resistance, in addition to extreme environmental conditions. The results indicated that foamed concrete block and panels can be used for infill purpose with improved performance and other characteristics.
Index Terms— Foamed concrete, Foaming agent, Compressive strength, Durability, Fire resistance,Precast blocks, Resistance to aggressive environment

1. INTRODUCTION

THE Construction sector is growing day by day with theInvention of new building materials like solid block, hollow blocks, interlocking block etc. In the case of multistoried structures, elements like partition walls, infill walls and parapet walls are non-load bearing. They impart a huge dead load on foundation and large number of vertical joints in them results in the propagation of cracks through that joints. To counter act the above-mentioned problems a new building material called light weight foamed concrete has been incorporated.

Several researchers concentrated their studies on foamed concrete with its high flow ability, low cement content, low aggregate usage and excellent thermal insulation .Furthermore, the foamed concrete is considered as an economical solution in fabrication of large-scale lightweight construction materials and components such as structural members, partitions, filling grades, and road embankment in fills due to its easy production process from manufacturing plants to final position of the applications. Low density of foamed concrete results in less weight, lowers haulage and handling costs and thus reducing the cost of construction making the structure more economical.

The production of stable foam concrete mix depends on many factors such as selection of foaming agent, method of foam preparation and addition for uniform air-voids distribution, material selection and mixture design characters. Mechanical and chemical methods are mainly used to generate the air voids in foamed concrete.

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LITERATURE REVIEW

3.2 Fresh State Properties

As foamed concrete have ability to flow and compact by itself, these two properties are evaluated based on stability and consistency of foamed concrete which are greatly affected by the water content in the base mix, amount of foam added in the mix.

2.1.1 Consistency

The researches proved that, when fly ash is replaced by sand, the consistency of the mix is reduced due to higher fine content of fly ash. Hence to satisfy the consistency requirement, an increase in water–solids ratio is adopted with an increase in fly ash replacement level. Foam stability also affect fly ash mixes. The consistency of foamed concrete reduces with an increase in volume of foam in the mix, which may be attributed to the (i) decreased self- weight and greater cohesion resulting from higher air content and (ii) adhesion between the bubbles and solid particles in the mix increases the stiffness of the mix.

2.1.2 Stability

The stability of foamed concrete is the consistency at which the density ratio (the measured fresh density/design density) is nearly one without any segregation and bleeding .This ratio is higher than unity at both lower and higher consistencies due to either stiffer mix or segregation. The additional free water content in foamed concrete due to foam collapse will cause an increase in actual w/c ratio. Thus, stability of the mix is affected by the consistency of the base mix to which foam is added. This consistency reduces considerably when foam is added and depends on the filler type also.

2.1.3 Workability

The presence of uniform air-voids in the fresh mix due to the addition of stable foaming agent imparts good workability and excellent performance to foamed concrete. The slum test, that are commonly conducted to find workability for the normal concrete is not applicable for low density fresh foamed concrete. Workability of foamed concrete is evaluated visually, which aims to achieve an appropriate viscosity of the mix. Spreadability method also can be used to measure workability of foamed concrete.

3.2 Physical Properties

The physical properties such as air void system and density are discussed in the following sections 2.2.1 and 2.2.2 respectively.

2.2.1 Air-void systems

The pore structure of cementitious material, predetermined by its porosity, permeability and pore size distribution, is a very important characteristic as it influences the properties such as strength and durability. Studies showed that, the pore structure of foamed concrete consists of gel pores, capillary pores as well as air-voids (air entrained and entrapped pores). Foamed concrete, being a self-flowing and selfcompacting concrete and without

coarse aggregate, the possibility of entrapped air is negligible. The air-voids in the foamed concrete can be characterized by a few parameters like volume, size, size distribution, shape and spacing between air-voids. The air-void distribution is one of the most important micro properties influencing strength of foamed concrete. Foamed concrete with narrower air-void distributions shows higher strength.

The use of fly ash as filler in foamed concrete helps in achieving more uniform distribution of air-voids by providing uniform coating on each bubble and thereby prevents merging of bubbles. At higher foam volume, merging of bubbles results in wide distribution of void sizes leading to lower strength. In addition to the air-void size and its distribution, the compressive strength of foamed concrete is also be influenced by the void/paste ratio, spacing of air-voids, number of air-voids. At the same time, for gas concrete, another type of aerated concrete, the expansion of concrete during gas formation result in the development of ellipsoidal oriented pores. Finer filler material helps in uniform distribution of air-voids. The ratio of connected pores to total pores in foamed concrete is lower resulting in lower air permeability compared to gas concrete, which leads to comparatively lower sound and water absorption in foamed concrete. The larger pores in aerated concrete can be treated as aggregate of zero density and a transition zone exists in the void-paste interface of such concrete analogous to the one in aggregate–paste interface of normal concrete. Thus, understanding the air-void system is essential for producing foamed concrete with a high strength-to-weight ratio with advantageous properties.

2.2.2 Density

Density can be either in fresh or hardened state. Fresh density is required for mix design and casting control purposes. According to researches of is that, a theoretical equation for finding fresh density may not be applicable. Many physical properties of foamed concrete depend upon its density in hardened state. The cement–sand based non-autoclaved preformed foamed concrete has relatively higher density and higher requirement of cement content. Greater the proportion of aggregate, higher will be the density. Alternately, to achieve a particular density of foamed concrete, use of fly ash results in a reduction in foam volume requirement due to its lower specific gravity, thereby resulting in higher strength.

3.2 Figures

Fig.2.3.1 Foam mortar mixing assembly

Fig.2.3.2Freshly prepared foamed concrete mix.

Fig.2.3.3 Foamed concrete poured in to mould

3. Fig.2.3.4 Casting of blocks

3 Experimental Programme

Experimental program was conducted upon literature survey in two phases. Phase 1 deals with material characterization and their testing. Phase 2 deals with blocks and panels. Material characterization is followed by development of foam, mix design and different tests on blocks

3.2 Material Characterisation

Material characterization was done for cement, fly ash and foaming agent.

- Cement

Ordinary Portland cement of 53 grade (Dalmia) conforming IS: 12269-1987 is used throughout the Research.

28-day compressive strength (N/mm2)	90-day compressive Strength(N/mm2)
2.22	2.6

Specific gravity	3.231
Fineness of cement	8%
Consistency of cement	30.5%
Initial setting time	90min

Fig 3.1 shows the physical properties of the cement.

- Fly ash

  Here class F fly ash conforming to IS 3812 part 1 2003is used. The fly ash was collected from Crystal clcMamala. The chemical composition of fly ash is shown below. The particle size distribution curve of fly ash done using mastersizer

- Foaming agent

  The foaming agent is capable of producing stable foam voids in concrete, which can resist the physical and chemical forces imposed during mixing, transporting, pumping, placing and setting of concrete. The foaming agent met the requirements of (9) of IS 9103 1999 and the foam produced shall be stable for duration beyond the final setting time of Portland cements
- Water

  The water used in the manufacture of the foamed concrete met the requirements of Is 456 2000 and shall be free from matter harmful to concrete or reinforcement, or matter likely to cause efflorescence in the units. Here Tap water was used for both mixing and curing.

3.2 DEVELOPMENT OF FOAM ANDMIX DESIGN

Potable water and foaming agent should be mixed in 1:50 proportion as prescribed by the manufacturer. Once diluted, emulsion must be used as soon as possible. The containers holding foaming agent must be kept at cool and airtight environment and under temperatures not exceeding 25°C. The foam generator assembly containing air compressor, various flow controlling valves

Mix Design done for block and panel was adopted based on previous literatures [5] by trial and error method. Its general rules are based on water/solid ratio, free water content etc. The target plastic density that becomes a prime design criterion, because it is difficult to design for a specific dry density as the foamed concrete will desorp between 100 and 200 kg/m3 of the total mix. Depending on the concrete plastic density, early curing regime and subsequent exposure conditions this value varies.

As per IS 2185 part 4 2008 minimum density required for cellular light weight concrete is 800 kg/m3. In order to achieve this density three trial mixes FC1, FC2, FC3 were prepared with different proportions of cement and fly ash in the ratio 375:375,250:500,500:250

kg/m3respectively. Initially the constituent materials were weighed and dry mixing was carried out for cement and fly ash. This was thoroughly mixed and then the water was added incrementally to obtain a good working mix. A water to solid ratio of 0.35 adopted throughout the research. 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 for two minutes. The mixing was done at a rate of 30 revolutions per minute

3.2 TESTS ON BLOCK AND RESULTS

3.5.1 Compressive Strength

4.2 WATER ABSORPTION

The water absorption properties provide the best information about the durability of cementitious composite. Water absorption is inversely proportional to density. The water absorption test was done with target density of 800kg/m3. The average value obtained 10.2% is less than 12.5% as prescribed by the code IS 2185 part 4 2008. It was investigated that the increase in fly ash/cement ratio in the mix proportionally increased the water vapor permeability especially at the lower densities.

4 CONCLUSION

The conventional block units in framed structures that are used as infill wall impart a huge dead load on foundation. The reduced density foamed concrete blocks and panels acts as a perfect solution to the above-mentioned problems.

Major Achievements

This study has established the feasibility of light weight foamed concrete with better exposure to elevated temperature and thermal comfort to the occupants. Superior performance in aggressive chemical environment is a positive feature of this work.

Major achievements are listed below.

- Light weight foamed concrete using fly ash and cement in precast blocks
- Light weight blocks and panels with compressive strength prescribed by the code has achieved.
- Better performance in aggressive environment were observed
- The foamed concrete can with stand high temperature and excellent thermal comfort to the occupants.

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