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Review on Feasibility of Fibre Reinforced Foamed Concrete Block

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Abstract
Foamed concrete block is a type of masonry unit manufactured by precast technique. Foamed concrete is produced by the mixing of Portland cement, sand, water and air voids are entrapped in the mortar of mix by means of suitable foaming agent. Due to its reduced density, foamed concrete is prone to micro cracking which results in loss of strength. To counteract the development and propagation of micro cracks, Polypropylene Fibres(PPF) are used to reinforce the foamed concrete. In this experimental study the feasibility of fibre reinforced foamed concrete block as an alternative to the conventional masonry units has been investigated by partially replacing the cement with kaolinite clay. Specimens are prepared by optimum percentage of fibre and optimum percentage of clay partially replaced by the cement. Compressive strength, water absorption test are to be carried out to find the properties of the foamed concrete block.

Keywords: *Foamed concrete block, Polypropylene fibre ,kaolinite Clay.*

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I. INTRODUCTION

The quest for finding a light weight material as a replacement for conventional masonry units has been there since nearly three decades. In India, over the past two decades a significant time has been utilized for making attempts to promote foamed concrete blocks as an alternative to the conventional masonry units.The use of foamed concrete blocks as a load-bearing masonry unit, at present, is very much limited, in the Indian context. Only recently in a very few reinforced concrete framed buildings, foamed concrete block masonry is used in place of conventional masonry in-fill. There is hardly any example of foamed concrete block units being adopted in load bearing structures. It is in this context that the present research work finds its back ground. Also, there has been scanty literature on the performance of foamed concrete block masonry as a structural member, in India, whether as a load bearing member or as a masonry in-fill reinforced concrete frames.

Foamed concrete is a cellular concrete of light-weight having a density ranging from 300-1800 kg/m3[1] It is produced by mixing of cement, sand, water and preformed stable foam. It has unique properties such as high flow ability, low self- weight, fire resistance and thermal insulating properties, minimal consumption of aggregate and controlled strength. It can be placed easily by pumping and does not require compaction, vibrating or levelling. It has excellent resistance to water and frost. Due to distinctive properties of foamed, it has found many applications in civil and structural engineering areas. For example, the low density foamed concrete has been used for cavity filling and insulation while the high densities were used in structural applications. Other applications of foamed concrete include production of lightweight blocks and pre-cast panels, fire insulation, thermal and acoustic insulation, road sub base, soil stabilization and shock absorbing barriers for airports and regular traffic etc. [2]

Though the elimination of coarse aggregates allows the foamed concrete to achieve reduced density, it also makes it prone to shrinkage cracks, thus directly affecting its strength parameters compared to the traditional concrete To strengthen concrete, steel bar reinforcement is a potential solution, but this leads to increase in density of concrete as well as undesired effects such as corrosion. Another viable solution is to reinforce concrete with fibres. Fibres can be natural as well as synthetic; each fibre provides different characteristics to the concrete in which it is being used to reinforce. However, in recent years the use of PP fibres has increased. These fibres are relatively cheap and can be chopped into desired sizes; they are durable in the environment of cement matrix, and major advantage over steel bar reinforcement is that PP fibres do not rust. PP fibres are commonly incorporated in structural- grade concrete to enhance flexural toughness, post-cracking response and resistance to energy and impact loadings. It was determined that the addition of PP fibres significantly increased the compressive strength as well as increased its stiffness.[3]

Soil-based construction materials have been used for centuries. In recent years, the soil which can be used as an eco-friendly building material has attracted lots of attention. It can be moulded into any shape or size with least effort. Clay was selected as the choice of material for various favorable reasons including the commercial considerations, natural availability and recyclable nature of clay. Clay in dried state has a porous structure which is filled with air, thus providing the best of the insulation properties largely useful to regulate the temperature that is keeping cool in summers and warm in winters [4]

II. LITERATURE REVIEW

The main aim of this section is to present an overview of research work carried out by various researchers in the field of foamed concrete block.

2.1 CEMENT

Current global Portland cement production is about 4.6 billion tonnes annually, with 6 billion tonnes predicted by 2050, while India's production capacity has seen a substantial rise from 98 MTs in 1996 to 445MTs in 2020 i.e., a 300% jump [5]. The conventional cementitious mix is a three-phase system consisting of cement, aggregates, and water of which cement and aggregates have their sub-phases. While aggregates may be either fine or coarse, the major sub-phases of cement are – Tri Calcium Silicate(C_3S), Di-Calcium Silicate(C_2S), Tri Calcium Aluminate (C_3A), and Tetra Calcium Alumino Ferrite(C_4AF), where, C = CaO; S = SiO_2; A = Al_2O_3; F = Fe_2O_3.[6]. Portland cement is also the most energy-intensive component of a concrete mixture and therefore its partial replacement by any cementitious by-products might result in significant energy savings [7].

2.2 FINE AGGREGATE

Fine aggregate material has been widely used for manufacture of concrete for use in buildings and other infrastructural Fine aggregate in concrete assists in producing workability and uniformly in mixture, reduces the shrinkage of binding material and it prevents the development of a crack in the concrete.[8] There is considerable pressure in many countries to use secondary and recycled aggregates in construction because of the environmental problems associated with production of primary aggregates (river sand). These include rock sand, quarry dust and manufactured sand. These fine aggregates are often manufactured by crushing and processing hard rocks to produce fine-grained materials Most developed countries use manufactured sand produced from crushing and processing of hard rock like limestone, sandstone and igneous rocks, whose aggregate properties are well researched [9].

2.3 KAOLINITE CLAY

Kaolinite is a non-swelling type of clay and exhibits limited shrinking and swelling with variations in its water content. It is a soft, earthy, usually white mineral produced by the chemical weathering of aluminum silicate minerals like feldspar. Kaolin is desirable in cement systems because of its pozzolanic activity, it can accelerate the hydration of Portland cement in the concrete mix and enhance the concrete product's mechanical properties [10] .Clays containing kaolinite are a promising choice due to their widespread availability. Kaolinite content is the major factor controlling the performance of blended cements incorporating calcined clay[11] Blends of kaolinite–bentonite clays, containing initially 35% crystalline kaolinite prior to calcination, achieved roughly 10% increase in compressive strength over samples containing 100% cement, at 90 days. Blended kaolinite SCMs may offer significant advantages as a low-cost alternative binder or cement replacement material, with the ability to maintain or enhance mechanical strength[12].

2.4 POLYPROPYLENE FIBRE (PPF)

PP fibres are synthetic and chemically new- generation fibres. Polypropylene is formed by polymerization reaction. Polymerization reaction in which many propylene molecule monomers join together to form one large molecule cell polypropylene . Fibrillated PP fibres, which consist of interconnected fibres of 12 mm length were utilized with specific gravity of 0.9.[13] These fibrillated fibres can reduce plastic shrinkage and permeability while simultaneously improving the impact and abrasion resistance, fatigue and cohesiveness It complies with ASTM C 1116, ACI committee report 544-1R, European Standard EN 14889 – 2 : 2006, Fibers for concrete Part 2: Class 1b[14] When PPF is added in concrete, the three-dimensional random distribution network structure can be formed in concrete, which effectively inhibit the microcrack generation and development . As a result, the PP fibre can prevent water and other harmful ions entering into concrete. The durability of concrete can be improved by adding PPF. Due to the excellent properties, PPF can be used in architectural engineering, pavement engineering, and hydraulic engineering. In architectural engineering, the foundation construction of high-rise building needs to be poured mass concrete at one time. The mass concrete is easy to produce thermal cracks at the early age. The PPF can effectively reduce the temperature cracks of the concrete [15]. Moreover, the resist-permeability of the concrete can be enhanced by adding PPFs due to less through cracks in the concrete

2.4 FOAMING AGENT

Foam bubbles are defined as enclosed air-voids formed due to the addition of foam agent. The foam agents are commonly synthetic, protein based, detergents, glue resins, hydrolyzed protein, resin soap, and saponin. The most common foaming agents are synthetic and protein based. The protein based foam agents results in a stronger and a more closed-cell bubble structure which permits the inclusion of greater amounts of air and also provides a more stable air –void network while the synthetic ones yields greater expansion and thus lower density[16]. The foaming agents from animal hydrolyzed proteins are the most widely used. They are from the recovery of animal by-products by alkaline hydrolysis of a protein-containing product obtained by fermentation. It is produced with not-too-complex chemical process methods. The foaming agent from animal protein presents some advantages: a high expansion rate of foam; -a thick wall between bubbles; -long-time foam stability; - a very low cost [17]. For improving thelong-time stability of the foaming agents, different complementary additives such as gel and surfactants are necessary.

2.5 FOAMED CONCRETE BLOCK

Foamed concrete blocks may be used for construction purpose, which is advantageous in terms of general construction properties as well as eco-friendliness. Their study shows that the use of fly ash in foamed concrete can greatly improve its strength properties.[18]. Foamed concrete blocks can be used for load bearing and non-load bearing structures Compressive strength is found to be increasing with the increase in dry density and with increase in fly ash content. Thermal conductivity is observed to be reduced by the addition of fly ash content.[19]

III. CONCLUSION

From the study of fibre reinforced foamed concrete masonry block following conclusions were obtained

- As the dosage of foaming agent increases both wet and dry density of the foamed concrete decreases.
- Optimum amount of foaming agent obtained as 0.25 L/100 kg cementitous material
- On the addition PP fibre compressive strength increases upto optimum percentage and then decreases.
- Optimum percentage of PP fibre obtained as 0.25 percentage.
- AS the addition of Kaolinite clay increases the compressive strength decreases.
- Optimum amount of Kaolinite clay obtained as 5%

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