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Revision Of Physical & Mechanical Properties Of Foamed Concrete

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Abstract- Lightweight concrete is concrete with a low density, due to which it has several other properties, like low self-weight, and also exhibits good thermal and acoustic insulation. Foamed concrete, a type of lightweight concrete, is prepared by mixing the preformed, stable foam with cement, thus causing cellular structure when hardened. In the modern construction business, lightweight concrete is still a crucial component since it combines the benefits of construction and insulation materials and is distinguished by its rip-roaring thermal qualities, moderate strength, and low density. Foamed concrete is a composite material with a density that is significantly lower than standard concrete. The water-to-cement (w/c) ratio in foam concrete typically ranges from 0.4 to 1.25. When the ratio is lower, the mixture becomes too stiff and the bubbles break, while when the ratio is higher, the mixture becomes too thin and the bubbles separate from the mixture. In the present study, a review of literature on different replacement materials for fine aggregate and different foaming agents was discussed.

Keywords: light-weight concrete, foamed concrete, compressive strength, thermal conductivity

Introduction

Light-weight concrete is still an important material in the modern building industry. It combines the positive properties of constructive and insulation materials and is characterized by moderate strength, low density, and ripping thermal properties. FC is another kind of cellular concrete that is produced by the aeration of cement mortar using foaming agents. By controlling the ratios of cement, sand, water, and foaming agent, a wide range of densities can be achieved, depending on the application. The non-structural components require building materials with low density, which can reduce the load on structures and construction costs. Foam concrete is also known as low-density cellular concrete (LDCC) and lightweight cellular concrete (LCC). No coarse aggregate is utilized in the manufacture of foam concrete. Another name for it is "foamed cement." Foam concrete typically ranges in density from 300 kg/m3 to 1600 kg/m3. Foam is typically used to replace all or a portion of the fine aggregate to reduce density. Advantages of foamed concrete include low density and high strength, high fluidity, self-compacting, resistance to cold and warmth, acoustic insulation, and fire resistance. Fig. 1 shows the method of

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preparation of foamed concrete, and Fig. 2 shows the applications of foamed concrete based on different densities. Utilizing fly ash in the slurry mix for foam concrete is less expensive and has a smaller negative environmental impact. By adding different foaming agents, which come under natural and synthetic-based foam, concrete is prepared. Natural foaming agents are obtained from textile industries, while synthetic foaming agents are generated based on technical requirements. Different applications of foam concrete include bridge abutments, pavement bases, tunnel stabilization, mass void fill, and structure fill. Table 1 shows the properties of foamed concrete based on different densities.

2. Literature review

Khawaja et al. (2021) [1] “Eco-friendly incorporation of sugarcane bagasse ash as partial replacement of sand in foam concrete”. The author of this research substituted sugarcane bagasse for sand in foam concrete. In comparison to control foam concrete, the microstructural, thermal, fresh, physicomechanical, and bagasse ash incorporation capabilities of foam concrete are presented in this study. 10% of sugarcane bagasse ash is seen to have been added to the foam concrete mix. highest increase in compressive strength (14.50%) and minimum decrease in thermal conductivity (10.76%) as compared to the control mix. Sugarcane bagasse ash replaces sand in foam concrete in an environmentally responsible manner without compromising its mechanical characteristics.

Namsonea et al. (2017) [2]. “Durability Properties of High-Performance Foamed Concrete”. The author of this paper discussed low density, excellent thermal characteristics, and moderate strength. Another type of cellular concrete is FC. Depending on the application, a variety of densities can be achieved by aerating cement mortar with foaming agents and controlling the ratios of cement, sand, water, and foaming agent. FC is created with cement mortar, a foaming agent, and no additional heat processing. It is crucial to take FC durability into consideration, particularly in cold and damp environments. Mechanical strength, water absorption, and frost resistance are key factors in durability. Additionally, shrinkage (including shrinkage from carbonation) needs to be taken into account. Carbonation processes are sped up by a material's low density and high open porosity.

Habsya et al. (2018) [3] “Physical, mechanical, and thermal properties of lightweight foamed concrete with fly ash”. The purpose of this research is to determine how the fly ash content affects the density, thermal conductivity, compressive strength, and water absorption in lightweight foamed concrete (LFC). Cement, water, sand, fly ash (FA), and foam make up this LFC. A 1:1 water-to-cement ratio and a 1:4 cement-to-aggregate ratio are used to create LFC. Sand and FA made up the aggregates, which varied in weight by 0%, 10%, 20%, and 30%. Foam made up between 30 and 40 percent of the volume of the mortar. The density, thermal conductivity, and compressive strength of LFC all drop as foam content rises. That, however, makes it absorb more water. Along with decreasing water absorption, FA content also affects density, thermal conductivity, and compressive strength.

Hashim et al. (2021) [4] “Comparative study on the performance of protein and synthetic-based foaming agents used in foamed concrete”. The effects of various foaming agents, such as protein-based versus synthetic-based foaming agents, on the characteristics of foamed concrete are empirically investigated by the author in this work. Experimental research and analysis were done on the foam stability, compressive strength, and drying shrinkage of the foamed concrete specimen. In this work, the microstructure, or the size and distribution of the pores, has also been characterized in order to better understand how the foaming agent affects the characteristics of foam concrete. Both foamed concrete's compressive strength increased as density increased; however, the protein-based foamed concrete performed better, having a 13% greater strength than the synthetic foamed concrete at a density of 1200 kg/m3. At a density of 1200 kg/m3, protein-based foamed concrete was shown to shrink 29% less throughout the drying process than synthetic foamed concrete. Thus, this study shows that the features of foamed concrete would be improved by the application of protein-based foaming agents. enhanced qualities of foamed concrete.

Mohd et al. (2017) [5] “Applications of Foamed Lightweight Concrete”. The author talked about foamed concrete with densities between 400 kg/m3 and 1600 kg/m3, and an improvement in the workability and bond adhesion will also increase the flexural and tensile strength. The strengths of foamed concrete Foam concrete is developed between 100 kg/m3 and 15000 kg/m3 and is also used in housing applications, prefabrications, and cast-in place walls, either load-bearing or non-load-bearing structures.

Hameed et al. (2021) [6]. “Experimental Study on Foam Concrete”. In this study, the author studied the effect of the mechanical properties of foamed concrete on the replacement of cement with 0%, 10%, and 20% flyash, as well as the addition of fibers at dosages of 1% and 1.5%. It was observed that the compressive strength of foamed concrete is about 5 N/mm2 when cement is replaced with flyash at a 10% dosage, and with the addition of fibers, the split tensile strength increased when compared to conventional mix.

Song et al. (2021) [7]. “Collaborative disposal of multisource solid waste: Influence of an admixture on the properties, pore structure, and durability of foam concrete." In this, the author substituted By using three-factor and three-level orthogonal tests, samples of fly ash, furnace slag, and mineral powder are used to examine how admixtures affect the characteristics, pore structure, and durability of foam concrete. According to the findings, foam concrete can have a range of mechanical and thermal insulating qualities, depending on the admixtures used. Foam concrete can have a compressive strength of 3.90 MPa and a thermal conductivity of 0.1347 W/M-k. Inorganic solid waste from multiple sources can be used sustainably and cleanly with the help of the advice in this paper.

Fallian et al. (2018) [8] “Experimental investigation on the compressive strength of foamed concrete: Effect of curing conditions, cement type, foaming agent, and dry density”. The initial findings of an ongoing experiment involving foamed concrete are presented in this study. Here, it is explored how cement type, dry density, water content, curing conditions, and, most crucially, the foaming agents used in the cement paste affect compressive strength. This experimental study includes more than 100 foamed concrete specimens with a fixed water/cement ratio, dry densities ranging from roughly 350 to 850 kg/m3, two types of cement, three foaming agents of either a protein or synthetic nature, and curing conditions in water at 30 °C, in air, as well

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as inside a cellophane sheet at environmental temperature. When protein foaming agents are used in the mix design, it is discovered that the increase in compressive strength with density is more or less represented by a linear trend.

Johnpaul et al. (2020) [9] "High Strength Lightweight Foam Concrete". This study aims to create foam concrete with high strength and low weight. The primary goal of the study is to use readily accessible resources to strengthen foam concrete. For practical construction in civil engineering applications, foam concrete is a creatively applied science. Only trial mixtures are used to carry out the complete ratio. For 7, 14, and 28 days, the cube has been prepared. The cube should not be submerged in water because there is foam present; only dry curing has been done. According to the compressive strength results, the ratio with the maximum compressive strength can be used to make CLC blocks as well as fill concrete.

Mohammad et al. (2018) [10] "Flexural Strength of Lightweight Foamed Concrete Using a Cement-to Ratio of 3:1 with the Inclusion of Polypropylene Fiber". In this study, the investigation of the compressive and flexural strengths of LFC in combination with polypropylene fibers is described. This study used a 3:1 cement-to-sand ratio. All samples were examined at the desired density of 1500. LFC design now includes polypropylene fiber with volume fractions of 0.25% and 0.40%. mixtures. The purpose of the foamed concrete was to get the desired effect from the volume proportion of Different polypropylene fibers that have cure times of 7, 28, and 60 days are employed.

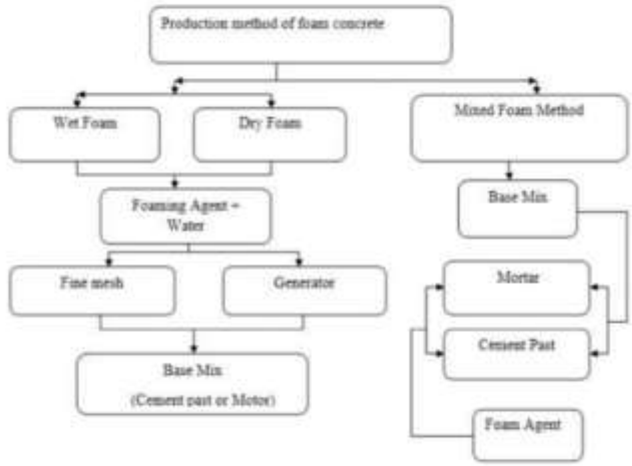

Fig. 1 - Method of preparation of foamed concrete

Density (kg/m^3)	Application
300-600	Replacement of existing soil, soil stabilization, raft foundation.
500-600	Currently being used to stabilize a redundant, geotechnical rehabilitation and soil settlement. Road construction.
600-800	Widely used in void filling, as an alternative to granular fill. Some such applications include filling of old sewerage pipes, wells, basement and subways.
800 - 900	Primarily used in production of blocks and other non-load bearing building element such as balcony railing, partitions, parapets, etc.
1100-1400	Used in prefabrication and cast-in place wall, either load bearing or non-load bearing and floor screeds.
1100-1500	Housing applications.
1600-1800	Recommended for slabs and other load bearing building element where higher strength required.

Fig. 2 - Foamed Concrete Applications Based On Density [5]

Table 1: Typical properties of foamed concrete based on Literature [5]

Dry Density (kg/m^3)	Compressive strength (N/mm^2)	Thermal Conductivity (W/mK)
400	0.5 – 1.0	0.10
600	1.0 – 1.5	0.11
800	1.5 – 2.0	0.17 – 0.23
1000	2.5 – 3.0	0.23 – 0.30
1200	4.5 – 5.5	0.38 – 0.42
1400	6.0 – 8.0	0.50 – 0.55
1600	7.5 – 10.0	0.62 – 0.66

Table 2: Mechanical Properties Based On Foaming Materials

FOAMING AGENT	Compressive strength	Thermal conductivity	Split tensile strength
Protein based	6.5MPa	0.1 W/M-k	
Synthetic based	4.5 MPa	0.32 W/M-k	-
Polypropylene Fiber	12.7 MPa	0.37 W/M-k	4.96Mpa

Table 3: Mechanical Properties Based on Materials

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FOAMING MATERIALS	Compressive strength	Thermal conductivity	Split tensile strength
Sugarcane Baggase Ash	3.20 MPa	0.150 W/M-k	1.21 N/mm^2
Flyash	5.80 MPa	0.1347 W/M-k	0.71 N/mm^2
Marble Sludge Power	7.26 MPa	0.180 W/M-k	1.13 N/mm^2

3. Conclusions

Based on the findings of this study, we draw the conclusion that adding foaming agents to concrete instead of fine aggregate will reduce the weight of the concrete itself and lower construction and shipping costs. We can acquire more benefits like economy and user-friendliness and deliver good exposure aspects since we have the best property and the least amount of self-weight. The compressive strength and density of foam concrete increase with age, and the compressive strength of foamed concrete also increases with an increase in density. Protein-based foaming agents have better compressive strengths when compared to synthetic-based foaming agents.

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